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OF
MALAYA.

ANNUAL REPORT 1928

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ANNUAL REPORT 1928.

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Including Initial Period beginning September, 1926.

GENERAL.

The growth of plantation agricultural enterprise within the tropics since the beginning of this century has been both rapid and far-reaching. It has been accompanied by a demand for scientific advice on and scientific investigation into the problems encountered by the planters. This demand was met at first by a rapid expansion of the staffs of Departments of Agriculture and more recently by the establishment of agricultural research institutes and of special research associations to provide for scientific work on particular crops.

Concurrently with the growth of plantation agriculture there has occurred a remarkable development of native agriculture on small estates or small holdings. This also has raised demands for scientific advice and investigation, and in certain crops such as rice, cotton, sugarcane and jute, much valuable work has been done.

Figures to illustrate the magnitude of this development are to be found in official publications of many countries, but perhaps the most striking picture is that presented by the rubber growing industry. A paper issued by the British Government (Cmd. 2883) gives the agricultural exports of the British Colonies in 1926 as amounting to £75,000,000 exclusive of rubber or to £171,000,000, if rubber be included, i.e. the rubber export is £96,000,000. India, not included in this figure, exported in 1926, rubber to the value of £1,960,000. The total 1926 export from the British Tropics is thus in the neighbourhood of £98,000,000, of which Malaya's share was approximately £63,000,000.

I. AGRICULTURAL RESEARCH IN THE EASTERN TROPICS.

The need for scientific investigation of the many and varied problems arising from the rapid development of agriculture in the tropics was recognised by Governments and it was provided for by augmentation of staffs and laboratories of the Agricultural De-

partments. These were at first on a small scale but owing to successive increases the provision now made by various Governments for agricultural research is of a most important and valuable nature.

Similar provision has been made by planting companies or groups of companies in the appointment of scientific officers to their staffs or in the creation of research stations. Notable instances of this are to be found in the rubber planting industry. The Rubber Growers Association established research stations in Malaya and Ceylon and the practical help given in this connection may be gauged from the fact that this Association has expended over £70,000 on its research stations in the 10 years following their establishment in 1911. The Rubber Growers Association still contributes to rubber research in Ceylon and South India. Another notable case is that of the Société Financière des Caoutchoucs which maintained a research station in Malaya from 1910 till 1922 at a total cost of £44,000. The Malay Peninsula Agricultural Association maintained a research station for many years and other instances may be added.

The following brief review of the provision made for agricultural research in various countries may serve to indicate its present position and to furnish comparisons which may possibly be useful and interesting.

India.

In India increased provision for agricultural research has been made by the establishment of Imperial Research Institutes and of Research Schemes under imperial auspices. Provincial Departments of Agriculture have been supplemented by Provincial Research Institutes, allied in some cases with the Agricultural Colleges, and by Research Schemes. These bodies are all financed and controlled by Government. Briefly there are 8 Imperial Research Institutes, 5 Research Schemes, and the Indian Central Cotton Committee. There are 4 Provincial Departments of Agriculture, 5 Agricultural Colleges and Research Institutes combined and 3 self-standing Institutes, and 19 Experiment Stations ranking as research centres.

Crop improvement work by the Agricultural Departments in the 1925-26 season resulted in a total area under improved varieties of $7\frac{1}{2}$ million acres, and of this $3\frac{1}{2}$ million acres were under improved cottons and $2\frac{1}{3}$ million acres under wheat.

The Central Cotton Committee has been formed to administer a fund for cotton research. The fund raised from a cess of 3 annas per bale of cotton exported or consumed in mills yielded over £52,000 in 1926-27; from which allocations are made for work on cotton at various centres. The Imperial Department of Agriculture

had an expenditure (rupee at 1s. 6d.) of about £72,000 in 1926-27 of which some £50,000 is on account of crop investigations at the Agricultural Research Institute at Pusa. The expenditure on four Imperial Farm Institutes was £34,700. The Provincial Departments of Agriculture, taken together, had a total expenditure of over £877,000.

In addition to the foregoing Government institutions there are certain special research stations not under Government control. These include the Scientific Department of the Indian Tea Association; a Tea Specialist under the United Planters' Association of South India at Nellakotta, and a Rubber Specialist under the same Association at Mundakayam.

The Scientific Department of the Indian Tea Association was established at Tocklai in Assam in 1910. It is supported financially by the Indian Tea Association, by the Governments of Assam and Bengal and by several Planters' Associations. Its revenue for 1925 was £16,344. The Rubber Mycologist Station at Mundakayam is under the control of a Committee on which the Rubber Growers' Association and the United Planters Association of South India are represented. To the support of the Station the United Planters Association of the South India contributed in 1926-27 the sum of £2,200; the Rubber Growers Association contributes £200 per annum and in addition has given a special grant of £500 for the installation of an electrical supply. The Tea Experimental Station at Nellakotta is controlled by the United Planters' Association of South India. Contributions of £1,245 to the Nellakotta Station and of £750 to the Scientific Department of the Indian Tea Association were made in 1926-27 by the United Planters' Association of South India.

The United Planters' Association of South India derives its revenue from a cess, voluntarily subscribed, on tea, rubber, and coffee, and from contributions of £1,860 by the Madras Government and of £450 from Coorg and Travancore States. In the 1926-27 Budget of the Association an allocation of £9,500, in round figures, is made to its Scientific Department.

The Government of Burma is considering proposals for the establishment of a Rubber Research Scheme in Burma.

Netherlands East Indies.

The recent publication (1929) of "Science in the Netherlands East Indies" permits of a brief description of the organisation of agricultural research at the moment of writing. The following summary is taken from it.

I. Government Institutions:—

- (1) General Experiment Station for Agriculture (Buitenzorg).
 - (a) Institute for Plant Diseases.

(b) Agricultural Institute, Experiment Garden, Seed Gardens.

(2) Forestry Research Institute (Buitenzorg).

(3) Government Rubber Plantation Laboratories.

(a) Agricultural Research Department (Buitenzorg).

(b) Laboratory of the Gutta-Percha Estate (Tjipetir).

(4) Agricultural Service, Department of Agriculture, Industry and Commerce (Buitenzorg).

(a) Scientific Commissioner for Freshwater Fishery.

(b) Horticultural Service.

(c) Division of Agricultural Economics.

II. Private Experiment Stations:—

i. West Java.

(5) General Tea Experiment Station (Buitenzorg).

(6) Rubber Experiment Station (Buitenzorg).

(7) Malabar Tea Experiment Station (Malabar, Bandung).

(8) Cinchona Experiment Station (Tjinjiruan, Bandung).

(9) Advisory Service of the Company for the Exploitation of the Pamanukan—and Tjiasem—Estates (Subang). (This is the Anglo-Dutch Company).

(10) Experiment Station for the Java Sugar Industry, Branch Station (Cheribon).

ii. Central Java.

(11) Central Java Experiment Station (Salatiga).

(12) Experiment Station for "Vorstenlanden" Tobacco (Klaten).

(13) Sugar Experiment Station of the United Klaten Plantation Co., Ltd. (Klaten).

iii. East Java.

(14) Malang Experiment Station (Malang).

(15) Experiment Station for the Java Sugar Industry (Pasuruan).

(16) Besuki Experiment Station (Djember).

iv. Sumatra, East Coast.

(17) Deli Experiment Station (Medan).

(18) General Experiment Station of the A.V.R.O.S. (Medan).

(19) Research Department of the "Rubber Cultuurmaatschappij Amsterdam" (Galang).

(20) Plantation Research Department of the United States Rubber Plantations Inc. (Bunut).

For the services enumerated there are thus 9 Government Institutions and 16 Private Stations. The latter could, perhaps, with advantage be divided into two groups namely, 12 co-operative research associations and 4 private research stations. Details are

given below as to the present annual income of these stations but complete figures are lacking as to recent income of the Private Experiment Stations.

Government Institutions.—The Department van Landbouw, Nijverheid en Handel (i.e. Agriculture, Industry and Commerce) is organised in 19 divisions including, *inter alia*, the Government rubber, cinchona and tea estates and the forestry, veterinary, industrial and commercial services. The expenditure on the following Agricultural and other services (taking the guilder at 1s. 8d.) amounted in 1927 to £225,332 as under:—

Departmental including Library and photographic workshop	... £37,750
Natural Science Services	... 20,000
Institute for Plant Diseases	... 7,416
General Experiment Station for Agriculture	... 30,583
Office for Agricultural Economy	... 1,333
Office for Agriculture	... 88,500
Central Office for Statistics	... 39,750
Total	... £225,332

The Government Rubber Estates of some 30,000 acres in extent yielded a net profit of £358,000 in 1927. These have inaugurated recently a research station, financed from their revenue, with a staff of five scientific officers. The Government Cinchona Estates yielded a net profit of £43,750 in 1927, and in 1926 made a contribution of £3,560 to the Kina (cinchona) proefstation. There is now under discussion the formation of a Coconut Research Station.

Private Experiment Stations.—In a note on the general organisation of these Stations for the large European-managed crops Dr. de Vries states that they were founded, more or less haphazardly, as the need arose, and later the various small, local stations were organised into larger units.

The sugar interests in East Java carried centralisation furthest and now have one big Experiment Station at Pasuruan.

The tobacco interests have maintained stations independent of one another, e.g. the Deli Proefstation in Sumatra and the Tobacco Proestation in Central Java. Here the interests of tobacco growers in different districts are dissimilar and they are better provided for by stations working independently. (Besuki Proefstation is an exception, tobacco being combined with the other upland crops).

The so-called Bergcultures or upland crops (rubber, coffee, tea, cinchona, etc.) formerly had a number of experiment stations run by different associations of planting interests. These stations are now being reorganised under the control of a central organisation

which has been set up for Java and South Sumatra the Algemeen Landbouw Syndicaat (General Agricultural Syndicate). The idea is to make one station central for each crop to control the work and take responsibility for the general programme, the other stations each to be central for another crop and to act as local representatives of the other stations (supervision of field experiments, local advisory service, etc.)

The East Coast of Sumatra, being a separate unit, has an independent general station (compare the Deli Proefstation) the Algemeen Proefstation der A.V.R.O.S. (Algemeene Vereeniging van Rubberplanters ter Oostkust van Sumatra).

The foregoing are the 'co-operative research associations'. In addition to these there are the 'private research stations' maintained by certain companies for their own work.

The latest figures available as to the incomes of the Private Experiment Stations where known are for 1923 and are given below. (The money is raised by an assessment on the planted area, which the estates in the association agree to contribute.

General Tea Experiment Station	... £ 8,000
Rubber Experiment Station	... 11,666
Cinchona Experiment Station	... 3,560
Vorst. Tobacco Experiment Station, Klaten	... 7,500
Malang Experiment Station	... 8,100
Java Sugar Experiment Station, Pasuruan	... 128,500
Besuki Experiment Station	... 8,450
Deli Experiment Station	... 16,666
A.V.R.O.S. Experiment Station	... 15,000
Total	... £207,442

It should be noted that in several instances the incomes have been increased on reorganisation and are now probably considerably in excess of the figures quoted. The Rubber Experiment Station figures are the sum of those for the Proefstation West Java and the Centraal Rubber Station as these have since been merged.

The success which has attended the work of the sugar, cinchona and tobacco research stations may be gauged from the position of these industries in commerce. Java exported 93 per cent. of the world's production of quinine, valued at just under £1,000,000 in 1923. Sumatra cigar wrapper leaf owes its continued, successful cultivation to the work of the research station on soils and disease control. Tobacco exports in 1923 were valued at £7,000,000. The sugar industry of East Java owes its success, in great measure, to the plant breeding and soils work of the station. Sugar exports in 1928 amounted to £41,500,000.

The sugar research station at Pasuruan is the largest of all the stations in Java. It derives its income from a voluntary subscription fixed for 1925-1927 at five guilders per bouw (1.75 acres) planted under sugar. As about 250,000 bouws are planted annually the income is about 1,250,000 guilders.

The AVROS research station in Medan derives its income from an allocation out of an assessment of members of the Association at the rate of 1.25 guilders per hectare on 250,000 hectares.

Figures are not available for the research stations run by particular planting companies but it may be estimated that the combined annual expenditure of these stations is approximately 600,000 guilders or £50,000.

For the purpose of arriving at an estimate of present expenditure on crop investigations in the Netherlands East Indies the fact that incomes for 1927 are indicated in certain instances and for 1923 in others may be ignored, particularly as in the latter case the figures are now almost certainly higher than those given. We thus have the following:—

Institute for Plant Diseases	...	£ 7,416
General Agricultural Experiment Station	...	30,583
Government Rubber Estates Experiment Station	(estimated) ...	20,000
Private Experiment Stations	...	207,442
Planting Companies Research Stations	(estimated) ...	50,000
Total		£315,441

The estimated annual expenditure on the enumerated crop investigations is thus in the region of £315,000. If account is taken of certain increases in income which have undoubtedly occurred this estimate may be placed at approximately £350,000.

Ceylon.

In Ceylon to meet the growing need for research on the island's agricultural problems, the Department of Agriculture was expanded and successive augmentations of staff and extensions of laboratory accommodation were made. The Government contribution to the cause of agricultural research has thus been on an important scale. The planting industries have also been active in making provision for scientific investigation at non-official research stations, wholly financed and controlled by themselves or in conjunction with Government.

The earliest of the non-official stations was that maintained from 1909 till 1915 by a group of Ceylon company members of

the Rubber Growers' Association, when it was taken over by the Rubber Growers' Association. This station was merged in the Ceylon Rubber Research Scheme in 1921.

The Ceylon Rubber Research Scheme was formed in 1913, and was financed by voluntary subscriptions from a group of companies with a percentage grant from Government. Since the merging of its Station the Rubber Growers' Association now contributes to the Scheme. A movement has recently been started to raise funds for its support by a cess on exports of rubber and it has further had a Government loan of Rs. 1,000,000 toward the cost of establishing experiment stations. The annual revenue is about £8,000 in Ceylon and £2,000 in London, the latter sum, contributed by the Rubber Growers' Association, being devoted to the cost of work carried out at the Imperial Institute on its behalf.

The Tea Research Institute of Ceylon established in 1925 derives its revenue from a cess on exports of tea of 10 rupee cents per 100 lbs., collected by Government and handed over to the Institute. The Board of control consist of representatives of Planting interests, of smallholders and of Government. The revenue for 1927 was approximately £17,380 (rupee at 1s. 6d.). The Institute has received a Government loan of Rs. 1,000,000 for the purpose of establishing an experiment station.

It is now further proposed to inaugurate a Coconut Research Scheme along similar lines.

The expenditure in 1927 on certain services under the Department of Agriculture was as follows:—

Research, including Central Experiment Station	£21,114
Botanic Gardens	... 6,900
Agricultural Education	... 4,700
Divisional Experiment Stations and Agricultural Service	... 22,400
Total	£55,114

Thus on crop investigations a total expenditure of £43,514 (£21,114 plus £22,400) was incurred. The revenue of the Ceylon Rubber Research Scheme in 1927 was just under £10,000, of which the Ceylon Government contributed £5,000, the Rubber Growers Association £2,000, and local members of the Scheme £2,500. The revenue of the Tea Research Institute in 1927 was £17,380. Thus a total sum of just under £71,000 was available for crop investigations in Ceylon in 1927.

Malaya.

The rapid development of the rubber growing industry in Malaya was accompanied by a corresponding extension of the

Agricultural Department, which has been fruitful of results. Important contributions to our knowledge of the cultivation of rubber and the preparation of the product have been made in the publications of the Department. To facilitate comparison the 1927 Estimates of the Department may conveniently be classified under headings similar to those of the Ceylon Department. The figures given below are compiled from both Federal and State Estimates, for the Federated Malay States, and it should be noted that in respect of these items the expenditure estimated was actually incurred:—

Research including Kuala Lumpur Experiment				
Station	...	...	...	£26,900
Agricultural Education	...	...	...	3,000
Experiment Stations (Serdang etc.) and Field				
Agricultural Service	...	...	...	32,700
				£62,600

Among the non-official research stations, as has been indicated was that established by the Rubber Growers' Association in 1911 and maintained till 1926. It was then closed down on the establishment of the Rubber Research Institute. Its income based on the total Rubber Growers Association expenditure on research stations would average about £4,000 per annum, the Ceylon station having been smaller than the Malayan.

The Société Financière des Caoutchoucs formed its research station in Malaya in 1910 and maintained it till 1922, when it was closed down. It was financed and controlled by a group of companies in Malaya, Sumatra and Java. The total expenditure of this station in its life of just over 11 years was about £44,000.

The Malay Peninsula Agricultural Association founded a research station in 1910, which was financed by voluntary contributions from local companies. This was closed down shortly before the establishment of the Rubber Research Institute. Its average annual expenditure would be approximately the same as that of the Rubber Growers Association station at one time, though probably somewhat less in later years.

The Rubber Research Institute was established in September 1926 and the research and scientific work on behalf of the rubber industry was transferred to it from the Agricultural Department. At the same time, as has been stated, non-official research stations in Malaya were closed down. The Board of control consists of representatives of planting interests, of smallholders and of Government. The income of the Institute, with limitations in certain instances, is derived from a cess on exports of 10 cents (Straits

dollar) per picul (133½ lbs.) of rubber, and has averaged approximately £45,000 per annum for the last three years 1926, 1927 and 1928. In the period under review the cess has not been levied but its equivalent has been contributed to the Institute by the Governments concerned.

In certain cases planting companies have appointed scientific officers to their staff and maintain private research laboratories for their particular needs. Notable instances are the "Revertex" process of latex concentration in connection with which scientific investigations are being conducted on a rubber estate in Malaya. The Dunlop Rubber Company are carrying out special investigations in connexion with the development of their estates and the concentration of latex. Scientific officers have been appointed for similar objects to estates in three other instances.

On crop investigations, expenditure in Malaya may be taken as £59,600 in the Agricultural Department and £45,000 in the Rubber Research Institute, a total of £104,600 in 1927. If private research stations are included the total is probably considerably in excess of £110,000.

Recent Tendencies.

From the brief review, which has been given, it will be noted that the tendency has been in the case of British rubber research stations toward a concentration of effort resulting in the formation of one large research station in the place of the several smaller stations which previously existed. In Ceylon the Rubber Growers Association research station has been absorbed by the Ceylon Rubber Research Scheme. Similarly in Malaya the research stations of the Société Financière des Caoutchoucs and of the Malay Peninsula Agricultural Association and at a later date that of the Rubber Growers Association have been closed down with the establishment of the Rubber Research Institute.

The advantages of this concentration of effort are obvious. The most serious disadvantage under which a scientific worker in the tropics labours is his isolation from fellow workers. This is more pronounced where independent research stations are small and scattered. Amalgamation of effort is the surest way to ensure collaboration in work. Further, a larger revenue is available for one central station than could be for each of several small stations, and library and laboratory equipment can be on a correspondingly more generous scale.

The principal feature, however, has been the movement toward the establishment of research stations to deal with particular crops, funds for this purpose being raised by the growers concerned, while the stations are under the control of representative Boards.

In Malaya, rubber research work has been transferred from the Agricultural Department to the Rubber Research Institute.

In Java the sugar industry and in Sumatra the tobacco and rubber industries each maintain their own independent research stations. Five other research stations in Java are under the control of the Algemeen Landbouw Syndicaat, an association of representatives of various planting industries. To these stations work is allocated as follows, rubber to the Central Rubber Station; coffee and rubber to the Proefstation Midden-Java; tobacco, rubber and coffee to the Besoekisch Proefstation; coffee and rubber to the Proefstation Malang; and tea to the Proefstation voor Thee. In addition other minor crops are dealt with at these stations. Work on the crops mentioned has been closed down at the Department of Agriculture.

In Ceylon the Tea Research Institute and the Rubber Research Scheme have been established and a Coconut Research Scheme is under preparation. Here, however, a considerable amount of work on the crops concerned is still carried out at the Department of Agriculture.

The cess imposed on exports in the case of the Tea Research Institute in Ceylon is at the rate of 10 rupee cents per 100 lbs; in the Ceylon Rubber Research Scheme $\frac{1}{2}$ rupee cent per lb. is proposed; and in the Rubber Research Institute of Malaya it is at 10 Straits dollar cents per picul of 133 $\frac{1}{2}$ lbs. It is interesting to note the relation of the cess to the value of the crop concerned. This is given below for the years 1927 and 1928.

Tea Research Institute.

10 cents per 100 lbs. is	{	.106 per cent of the value of the crop exported in 1927.
		.117 per cent of the value of the crop exported in 1928.

Rubber Research Scheme.

$\frac{1}{2}$ cent per lb. is (proposed cess)	{	.131 per cent of the value of the crop exported in 1927.
		.211 per cent of the value of the crop exported in 1928.

Rubber Research Institute.

10 cents per picul is	{	.091 per cent of the value of the crop exported in 1927.
		.180 per cent of the value of the crop exported in 1928.

II. INDUSTRIAL AND AGRICULTURAL RESEARCH IN BRITAIN.

The objects and aims of industrial research i.e. the functions of an industrial research association, have been indicated by the

Department of Scientific and Industrial Research. The Advisory Council of the Department in its 1925-26 Report summarises the principal conclusions they have reached "as the result of intensive study of the present position of purely scientific and industrial research in this country and of the effects produced by the work of the Department during the last ten years."

They state that "the terms pure science, applied science, industrial research, *ad hoc* investigation, are frequently used, but not, we suspect, always with the same meaning. Let us therefore define pure scientific research as that type of research in which the advancement of knowledge regardless of its immediate practical importance is the end in view. Applied Scientific research (or industrial research) has two main objects—improvement of existing and introduction of new industrial methods and processes."

"Thus the research with which we are concerned is practical in aim, whether it be pure or applied research, and it shows this intention throughout. The choice among the multitudinous lines of advance is determined by the practical considerations of where the material advantage is most likely to lie. Between two problems both offering the same probability of solution, if success in one will produce a big saving or profit and in the other a relatively small improvement, there should be no difficulty in choosing. The difficulty often lies in estimating the relative importance of the alternative problems in the cost of production. This difficulty can only be removed by an economic study of the industry from the research standpoint. We are not sure that enquiries of this kind have been sufficiently prosecuted in the past by industrial research workers."

"The justification for all the expenditure on industrial research which we may recommend must rest in the essentially practical aim of the work; and in all the measures adopted by the Department to carry out or to promote industrial research, the primary purpose must be to secure the application of scientific knowledge in industry."

In their 1927-28 Report the Advisory Council state that the year has been notable for a marked development of industrial research and that the Industrial Research Associations, in spite of financial difficulties are gradually securing greater confidence of the industries they serve. There were 24 of these Associations in existence of which 18 have been established for 7 to 10 years. Government bore half the cost of these for the first 5 years, a justifiable proportion as co-operative research in industry was then an experiment of which no one could foresee the result. At the end of the five years owing to the difficulties of British industry and owing to the fact that five years proved too short a time for

most of the Associations to establish their reputation by the result of their work. State aid on a smaller scale was continued. They state that "co-operative research has proved its value and has come "to stay", and that "British industry is learning that "to support cooperative research does not mean the suppression "of individual enterprise; we note with interest how often the "strongest support of Research Associations comes from firms "which have large research laboratories of their own". They "urge that British industry must learn to alter its outlook and "where scientific investigation is concerned, to think in thousands "of pounds where it now thinks in hundreds, or even in tens". The council proposes that when existing financial contracts come to an end each Association should be considered on its merits and the Government grant be fixed accordingly.

Agricultural research in Britain is on the whole organised on lines similar to those on which industrial research is carried on. Its development on a large scale was subsequent to that of industrial research, the latter as distinct from the former receiving a strong stimulus under war conditions. Agricultural research as now organised is almost entirely a post-war development.

Higher agricultural education in Britain is provided at some 10 universities and 8 agricultural colleges. These Institutions carry out not only teaching but also research, advisory and extension work, in these matters each serving the needs of a definite area. Attached to these universities or colleges or quite independent of them are the 24 Agricultural Research Institutes which provide for fundamental research and scientific investigation of special problems. Investigations on Soils and Plants are carried out at 12 Institutes including the Rothamsted Experimental Station; the Horticultural Research Stations at Long Ashton, East Malling, Cambridge and Cheshunt; the Plant Breeding Institutes at Cambridge, Aberystwyth and Edinburgh; the Plant Physiology Institute at the Imperial College, London; the Seed Testing and Crop Improvement Stations at Cambridge and Edinburgh; and the Soils and Drainage Station at Aberdeen. Of the remaining 12 Agricultural Research Institutes 5 are devoted to Animal Nutrition and Breeding, 5 to Animal Pathology, 1 to Agricultural Economics and 1 to Agricultural Engineering.

The Agricultural Research Institutes have both a Research and an Advisory staff. While the Research staff is engaged on fundamental work and special problems of the crops with which they are concerned the Advisory staff is concerned with routine work in the district, does research and experiments on smaller problems, carries out field work in collaboration with the research staff and gives lectures to farmers' and growers' associations.

In addition to the above there are the County Council Farm Schools or Institutes. Here educational work is undertaken by the Instructors while the County Organisers do general advisory work, keeping in touch with the Advisory Officer of the Research Institute or Agricultural College.

The working of the system has been described as follows:—
 “Problems come from the farms to the County Organiser who
 “passes on such matters as are beyond his scope to the Advisory
 “Officer of the Research Institute. He, in turn, deals with all he
 “can and passes the remainder to the Research Officer. There is
 “thus a complete series of links between the farmer and the re-
 “search worker and in the reverse direction a definite channel for
 “the outflow and rapid dissemination of the research workers’
 “results.”

III. ORGANISATION OF THE RUBBER RESEARCH INSTITUTE OF MALAYA.

The Institute, as laid down in the Incorporating Enactment, has been established for the purpose of research into and investigation of all problems and matters relating to rubber and the provision of information in this connexion. The scientific work of the Institute will thus be directed toward establishing the facts underlying the cultivation and preparation of rubber and to the discovery and application of fundamental principles for the benefit of the industry. The Institute will also undertake the supply of scientific and technical information and will provide for the dissemination and utilisation in the industry of such new knowledge as it may acquire.

The revenue of the Institute is derived from a cess on rubber exports from Malaya. So far the cess has not been definitely imposed, the contributing Governments having made funds available on this scale out of the general revenue accruing from the rubber export duty. The revenue, thus derived, comes from the produce of large estates, small Asiatic estates, and small holdings. It is apparent then that the Institute is concerned with the needs of all rubber producers in the country. In paper No. 21 of * 1925 statistics are given showing that over 100,000 holdings under 25 acres (all Asiatic owned) and 1,700 between 25 and 100 acres (mostly Asiatic owned) in 1925 produced 44 per cent of the Malaya standard production of rubber. The larger estates, European and Asiatic, therefore produced 56 per cent of standard production in 1925.

In the past, scientific work for the rubber growing industry in the Eastern Tropics consisted of two main lines of research.

* Federal Council, F.M.S. Paper No. 21.

viz., chemical investigations into the preparation and properties of the product and pathological investigations into the diseases of the crop. Great importance was attached to disease work, perhaps owing to the impression made on the public by the disastrous effects of the coffee leaf disease in Ceylon, and, as a result of this general interest in pathological problems, biological appointments were generally given to "mycologists". The mycologist, however, as his work progressed and as he accumulated experience, found that he was frequently unable to advance further in his own investigations until the lack of information on basic physiological and soils problems was made good. In the absence of workers in these branches he had perforce to attempt the work himself or leave his own investigation incomplete. A study of the staffs of Colonial agricultural departments will reveal the fact that, besides pathology, in many cases the mycologist had to undertake responsibility for practically all crop investigations except entomology.

In recent years, however, the tendency in the Tropics both among scientific workers and practical planters, has been toward a deeper realisation of the fundamental importance of problems of crop improvement and soil management. In the rubber growing industry these matters are the burning questions of the day, and so urgent is the demand for information from the industry, that it is at all times necessary to emphasize the tentative nature of much of the existing information and to stress the need for investigation to establish the facts.

In planting circles, interest in crop improvement and soil management has been awakened firstly by the prospect of obtaining, through budding from high yielding trees, a greatly improved stand of trees from the cropping point of view and secondly by the marked results obtained on a certain type of poor soil from the application of nitrogenous manures. Interest has also been stimulated by the fact that the yield from old rubber trees in certain districts either remains stationary or tends to fall off. The work of the research associations in the Netherlands East Indies and its increasing importance to the industry there has had its effect in awakening a demand for a greater measure of scientific work in Malaya.

In organising the scientific work of the Rubber Research Institute it was considered essential that adequate provision should be made for investigations into crop improvement and soil management as central functions of the Institute.

An important process on rubber plantations, and one on which the market value of the rubber closely depends, is that of the preparation of rubber from latex. To provide for the investigation and information required by the industry and to examine new

methods of preparation necessitated the appointment of staff for this purpose.

Plant diseases have to be kept under constant observation and as new factors appear or new data are obtained control practices need to be modified and made more efficient. A true conception of pathological work includes all the causal factors producing disease directly or indirectly. This calls for a very thorough investigation into the pathology of the rubber tree in Malaya.

Further, in view of the nature of the investigations required, of the interrelated problems of "soil conditions and plant growth," and of the necessity, in face of our general lack of knowledge of tropical crops, of providing a team of workers capable of attacking the central problems simultaneously from different aspects, it was important that provision should be made for work to be inaugurated in the different branches of the Institute's activities at the same time.

With these matters in view provision was made for the appointment of research staff to four main divisions of the Institute, namely, the Botanical, Chemical, Pathological and Soils Divisions.

Field Officers have been appointed to work in conjunction with the Research Staff. The Field Officers are in general to be placed at the headquarters station of the Institute, and are to go out on tours of duty, returning to the headquarters on completion. The Field Officer's function is practically identical with that of the Advisory Officer of the British Agricultural Research Institutes, i.e., he has to keep in touch with the research staff at headquarters, carry out advisory and routine work for growers, and conduct experiments on smaller problems and undertake field work in collaboration with the research staff. Operating from headquarters, to which he returns on completion of a tour of duty, the Field Officer can keep in touch with the scientific work in hand, conduct his advisory correspondence and arrange his advisory tours of duty, and undertake field work particularly on the experiment station.

The Field Officers, on their frequent return to headquarters, will bring their field observations and the problems they have encountered on estates to the notice of the research officers concerned. The research officers will, thus, be enabled to keep in touch with conditions over many planting districts, and on the knowledge thus gained, they will be able to arrange their own visits to the planting districts to the best advantage. They will also be able to direct the Field Officers in the investigation of any problems which the latter may be required to undertake.

Part of the duty of the Field Officers is to investigate conditions on small holdings and small Asiatic estates. By this means information will reach the research staff of the Institute as to field conditions which will serve to indicate the lines along which

work can be most profitably directed on behalf of these growers. Information of importance to the whole planting industry may possibly be obtained in particular from a study of the method of dense planting adopted on small holdings and of the yield and disease factors.

The farm or experiment station must be regarded as an integral part of any agricultural research institute.

Since rubber is grown as a perennial crop and as, in its cultivation, an acre of land is made to carry only some 80 to 100 individual plants, it was evident from the beginning that an experiment station for research work on rubber, if it is to subserve this purpose adequately, must have at its disposal a considerably larger area of land than is usually devoted to annual crops in temperate zones. In addition to the plots, on which basic experiments are to be conducted, it is of some importance that larger areas should be available on which results obtained from small scale experiments can be tried out on a larger scale. Finally, a large area is necessary for the plant breeder to try out the results of his selection work.

From a consideration of these points it was concluded that an area of at least 2,000 acres would be necessary to make adequate provision for the rapid extension of work that is bound to come. Government has generously placed 2,000 acres of land at the disposal of the Institute for the purpose of its experiment station. This land is situated in the most convenient area of available forest reserve at some 15 miles from Kuala Lumpur.

The establishment of the Experiment Station will require a considerable outlay of capital, and a considerable annual outlay on maintenance. On the other hand, revenue should accrue from the Experiment Station when the rubber comes into bearing.

There must be, amongst planters of experience, a considerable body of information and of field knowledge which in general is not recorded and tends to become lost to the industry when a planter retires from the country. Much of this information is of great value, for example field results obtained from cultural operations. Such experience and information in farming circles at home usually finds its way into farming or agricultural journals, or become part of local tradition or of accepted farming practice and is thus preserved. Conditions on rubber estates in the tropics are unfavourable to the building up of an accepted practice or tradition owing to the comparatively frequent change in the personnel of any one district. Thus when the older planters retire from the country the knowledge and experience which they have gained is lost to the industry. It is desirable, therefore, that estate and planting information and experience be collected, summarised and

published. From these summaries many indications may be obtained of promising lines of investigation.

Accurate estate records may frequently be of great value in certain investigations as, for example, the effect of soil on yield. They will gradually be assembled in the course of work undertaken by both the Research and the Field Staff.

The summarising of much of this matter could usefully be undertaken in an Information Bureau. The Information Bureau has come to be a recognised portion of the mechanism of industrial research associations in Great Britain and its functions are as important to industry as they are to the research association. The functions of the bureau are mainly to act as a clearing house for information going out to or coming in from the industry. It should abstract current literature and prepare periodically a summary sheet or index. It would also assemble statistics and would endeavour by its own activities to supplement or complete those from direct enquiries.

The Library is an equally important charge of the Information Bureau, the value of the Library to those using it depending on the indexing of all subject matter to which reference is required, the issue of summaries of previous research work and the circulation amongst the staff of translations of papers in current periodicals.

The office is in charge of a Secretary whose duty it is to record the minutes of the meetings of the Board of the Institute and its Committees, to keep all office records and accounts and to attend to the business affairs of the Institute.

The general charge of the building and the maintenance and supervision of the plant and machinery installed is in the hands of the Curator. He is also in charge of the workshop where apparatus designed in the Institute for special investigations will be constructed.

In order that the work of the Institute may reach rubber growers and to provide them with the available information three types of publications will be issued by the Institute, namely, Bulletins, a Quarterly Journal and Planting Manuals.

As any piece of experimental work reaches a sufficiently advanced stage to show results of immediate economic importance to estates it will be published in the form of a special Bulletin. Bulletins will not appear at regular intervals as their issue will depend upon the progress of the investigations in hand.

The Quarterly Journal will contain shorter articles, summaries of current information, and notes on estate practice. It may also serve as a medium for the publication of progress reports of investigations in hand and of the activities of the Institute.

Manuals will be of the nature of text books and will form authoritative guides on plantation practice.

Arrangements have been made to issue in the Malay and Chinese publications of the Department of Agriculture translations of the Planting Manuals and of articles from the Quarterly Journal. These should serve a useful educational purpose and the Institute is indebted to the Department of Agriculture for these facilities.

A London Advisory Committee has been formed to link up the research work being carried out in Malaya with rubber research work in London and to effect a liaison with the Ceylon London Advisory Committee. The members of this Committee are as follows:—

- (i) One member nominated by the High Commissioner for the Malay States.
- (ii) Two members nominated by the Rubber Growers' Association, London.
- (iii) Two members nominated by the Research Association of British Rubber and Tyre Manufacturers.
- (iv) The Professor of Botany, Imperial College of Science, London.
- (v) The Director of the Rothamsted Experiment Station, Harpenden, Herts.
- (vi) The Director of the Imperial Institute, London.
- (vii) The Director of the Imperial Bureau of Mycology, Kew.

The last four appointments are ex-officio appointments. Alongside the work of the London Advisory Committee it is of great importance that the Institute should maintain the closest, direct contact with workers in Ceylon, South India and the Netherlands East Indies. Collaboration with officers of the Agricultural Department, S.S. & F.M.S., on problems of mutual interest will also be of mutual advantage. On many matters of scientific interest to the researcher in Malaya it will be found to be of the greatest advantage to keep in touch with research workers at home, and particularly with industrial research associations in their general policy and attitude towards the scientific needs of the industries for which they work. Programmes of work have been submitted for the consideration of the Board. These cover a wide field and may be regarded, in many respects, as a survey of the whole field of work as it presented itself at the time they were drawn up. These are now being considered by the London Advisory Committee.

A general Research Committee for the discussion and preparation of programmes of work has been established. This Committee consists of planting members of the Board of the Institute and of members coopted as required. The Committee also comprises the Director and the Heads of Divisions of the Institute.

The Committee has no executive functions being only advisory to the Board on the subject of the work to be undertaken at the Institute. It need not meet more frequently than twice per annum unless matters of urgency require it to be summoned. The advantages of bringing all parts of Malaya into active touch with the research work to be carried out at the Institute and of thus providing for the closest liaison between planters and research workers are apparent.

A meeting of Senior Officers with the Director has been inaugurated as an internal Laboratory Committee. Its functions are to discuss work in hand to report progress and to examine fresh problems as they arise.

The Institute has already received requests from rubber growing companies in British North Borneo and Burma for advice on planting problems, for investigational work and for Institute publications. It is an advantage to the Institute to have a knowledge of the problems which confront rubber growers in other countries. Such advisory work as is possible is being done by correspondence.

IV. WORK OF THE PERIOD UNDER REVIEW.

The period was essentially one of construction. Salary scales had to be drawn up, scientific staff had to be obtained and bungalows provided for their accommodation. A building suitable for use as a laboratory had to be modified and extended. The laboratory had to be equipped with benches, cases and shelving. The apparatus, chemicals and glassware required for the various divisions had to be obtained. A gas plant and a steam boiler had to be installed and a water supply provided. The laboratory had to be fitted with gas, steam and water pipes. A supply of electric current had to be specially arranged as the laboratory building was at some distance (about $1\frac{1}{2}$ miles) from the nearest supply point. A generator had to be installed to supply the direct current at 110 volts which had been decided on, and this and the switch-board had to be obtained from England. Land for the Experiment Station had to be selected and negotiations conducted for its acquisition. A system of accounts and the form of the estimates had to be drawn up. The Library had to be built up from the beginning, books and periodicals had to be acquired and exchanges sought. The experimental rubber factory, smokehouse and drying room attached to the Chemical Division had to be installed. And so on with the thousand and one lesser matters incidental to the inauguration of a new institution, the difficulties encountered being either unknown in similar circumstances in England or where known then occurring in an aggravated form owing to the distance from our source of supplies.

In the most favourable circumstances a number of years is bound to elapse before any new research institute can establish its reputation by its work. In "Nature" (18th May, 1929) the 1927-1928 Report of the Department of Scientific and Industrial Research (Curd. 3258) is discussed in the leading article, from which the following quotations may appropriately be made.

"In fact, as the report of the Advisory Council the Department states candidly, 'five years proved too short a time for most of the Associations to establish their reputation by 'the results of their work'.

"There need be no surprise at this conclusion, for the first two years of an association's life are necessarily spent mostly in setting up the organisation, gathering together the appropriate scientific staff, securing the buildings and equipment, and planning a comprehensive research programme. It would be more than remarkable if, in the remaining three years, the results of any association's work should be sufficiently striking to convince manufacturers (presumably having little or no previous experience of research applied systematically to their respective industries as a whole) that co-operative research was of such immediate and valuable service to industry that it would be a 'business proposition' for them to bear alone its necessarily high expense. St. Paul may have been amenable to quick conversion, but the average British manufacturer is, shall we say, less impetuous. Indeed, even now, after some ten years' experience of the work of the research associations, the report of the Advisory Council to the Department says: 'It cannot be denied that most of the Associations find it difficult to get the financial support they deserve. A subscription to a Research Association is still regarded in many cases as a charitable gift, to be paid with public spirit and private reluctance, and to be withheld when funds are scarce'."

As five years have proved too short a time for research associations in England to establish their reputation by their work, in the Tropics it would not be too much to allow a still longer period, having in view such circumstances as health and climate, delays in obtaining supplies, difficulty in obtaining staff on account of the reluctance of many scientific workers to take up residence in the Tropics, and the effect of breaks in the continuity of work owing to the necessities of furlough.

The Institute having reached the point of being in existence the first main task was to acquire a knowledge of the rubber planting industry on which to base our Programmes of Work, a matter of difficulty where the industry covers a stretch of country

some 500 miles long with a considerable diversity of soil and site conditions. Programmes of Work have been drawn up which are sufficiently comprehensive to be regarded as a survey of the whole field of work, and experience is indicating the directions in which work is most urgently required. Records of progress of work are given in the reports furnished by the Heads of Divisions and the Manager of the Experiment Station. It will be noted that important progress has been made in certain directions and that it has been possible to draw definite conclusions in some cases from field and laboratory observations.

On the Experiment Station, under Mr. D. S. Gardner's management, progress has been both rapid and substantial. It should be borne in mind that felling of the original forest was first begun as recently as March, 1928. Access to the Station by motor car was made possible by the construction of $1\frac{1}{2}$ miles of road by the Public Works Department. This road in due course will be continued through to the Batu Tiga—Subang road and will thus provide access to the Experiment Station from both North and South.

Important conclusions have been reached as the result of Dr. J. R. Weir's survey of rubber estates in the Johore River Region. The die-back which frequently occurs on certain sites is attributed to poor soil conditions rather than to fungi. Dr. W. B. Haines confirms this view and advises remedial measures toward the improvement of soil conditions.

In the Botanical Division the physiological work in the hands of Mr. C. E. T. Mann has added facts of definite economic importance to our knowledge of budding. Tapping experiments on budded trees conducted jointly with Dr. E. Rhodes have yielded valuable information which will aid in the further investigation of the fundamental problem of latex production. A technique for the microscopic investigation of the caoutchouc particles in latex has been worked out by Dr. E. Rhodes and Mr. H. Gunnery. Mr. L. E. Morris has made an excellent start with our breeding work and a considerable number of seedlings obtained by artificial pollination have now been planted out on the Experiment Station. He has also carried out work which has enabled us to identify members of clones where these have been mixed in the field. Mr. F. Billington has made a useful investigation on methods of packing budwood for transport.

In the Chemical Division, Major B. J. Eaton was on furlough during the latter half of 1928, and Mr. R. G. Fullerton acted. A considerable amount of work has been carried out on the effect of moulds on sheet and on the use of mould preventatives. Valuable information has been obtained from a field experiment on deep

and shallow tapping, an important effect on the dry rubber content of the latex having been noted. Much advisory work on the construction of smokehouses has been done.

A very complete series of plots has been planned by Dr. Weir for the Experiment Station for the study of field pathological conditions. These will also yield valuable information on general growth conditions. The standardisation of methods of root disease control is one of the main investigations in view.

A very considerable volume of advisory work on fertiliser trials on estates has been carried out by Dr. W. B. Haines, the resulting field data from 36 of these being reported to the Soils Division for discussion. Points under observation include the effect of fertiliser on yield, bark renewal and foliage and in encouraging the growth of cover plants. Many soils analyses have been made in response to requests from estates. The prevention of soil erosion and the rejuvenation of deteriorated soils are important lines of work in view.

A Field Survey of Smallholdings in Johore has been inaugurated.

A very interesting Survey was also made of the flooded areas in Kelantan by Dr. Haines and Dr. Weir, the field observations being recorded in the Divisional reports. Dr. Weir's observations on field conditions and Dr. Haines' examination of the flood silts point to the unsuitability of the flooded sites for rubber planting.

The following note is a summary of the position as it was recorded in April, 1927.

THE 1926-1927 FLOOD ON RUBBER ESTATES IN MALAYA.

Note on the position in April, 1927.

The December 1926—January 1927 flood in Malaya was accompanied by unprecedented inundation of rubber estates. This was severe on estates to the West of the Central mountain range particularly in Perak and Selangor. To the East, however, there was a deluge that overwhelmed estates in Pahang and Kelantan. In view of the great depth of flood water it is surprising that so little damage seems to have been done though the full effects may become manifest only after the lapse of some time.

Some idea of the extent and severity of the floods may be gained from the following extracts from the statement made by the Chief Secretary in Federal Council on 28th February, 1927.

“The floods that took place in Kuala Lumpur and Ipoh
“did not differ very materially from many that had happened
“there before. Those however that occurred up-country

“especially in Perak and Pahang may be termed unprecedented. I do not think that any ordinary human effort could have had any appreciable effect upon them. When waters rise from 70 to 100 feet above normal level, it is obvious that mere man can do very little in the matter. I think that there is very little doubt that a good deal of the flooding was caused by a succession of cloud-bursts throughout the country, similar to the one that happened quite recently in this State and did a very great deal of damage in a very short time.

“The State of Perak suffered very considerably. One or two bridges near Kuala Kangsar have been destroyed. The road to Grik had been cut in half at one place. Over 60 miles along the Perak River, both up and down from Kuala Kangsar, practically the whole way showed signs of heavy erosion from the floods, and a great many rubber plantations had lost strips of land into the river. Here and there a bridlepath had disappeared entirely. What was remarkable was how the bridges had stood the strain. In certain places we saw immense trees, true giants of the forests, which had been carried down for miles, and simply thrown aside like corks by the river when it had finished with them.”

“In Pahang, the situation was much more serious. Kuala Lipis, Raub, Bentong, Chigar Prah, Temerloh, and Jerantut were all more or less isolated. They were all separated from each other, and constituted more or less islands in the State. The areas that must have been absolutely swamped under water are enormous. The Railways are getting through more quickly than was at one time anticipated. It will probably be some months before they can get through to Kuala Lipis.”

“In Kelantan the destruction has been very heavy; 168,000 acres of padi were affected, and it is estimated that nearly one-third of that area will be actually ruined, finally and fully.”

In order to obtain information as to the nature and effect of the floods on rubber estates for the purposes of record and subsequent investigation at the Rubber Research Institute a suitably framed questionnaire was addressed to the principal agency firms in Malaya. From the replies received and from additional information from other sources the present summary has been drawn up. Out of some 500 estates covered by the enquiry 50 estates recorded flooding of a greater or less extent. Though it is believed that the information given below is fairly representative of the floods it should not be regarded as complete.

The districts in which flooding occurred on rubber estates may be classified as follows:—

Kedah	(i)	Muda River.
Perak	(ii)	Krian River.
„	(iii)	Teluk Anson.
„	(iv)	Inland Perak.
Selangor	(v)	Kuala Selangor.
Negri Sembilan		
Johore	(vi)	Muar River.
Malacca		
Pahang	(vii)	Temerloh.
„	(viii)	Kuantan.
Kelantan	(ix)	Kelantan River.

- (i) Muda River. Estates in this area are liable to annual flooding usually in the months of September, October and November. The present flood occurred in December and is the highest on record.

Duration of flood: 11 to 21 days.
 Depth of flood: 5 ft. to 20 or 30 ft.
 Estate area flooded: 700 acres (approx.)
 Silt deposited: negligible.

- (ii) Krian River. This area is subject to periodic flooding and in the present instance the flood was widespread and reached the highest level on record.

Duration of flood: 11 to 23 days.
 Depth of flood: 2 ft. to 3 ft.
 Estate area flooded: 7,500 acres (approx.)
 Silt deposited: negligible.

- iii. Teluk Anson. Floods came from the Perak River. This area is liable to floods, the present being the highest recorded. It is noteworthy that the onset of the inundation in Teluk Anson was about a week later than in districts further inland, and this apparently represents the time taken by the flood waters of the Perak River to reach the river mouth.

Duration of flood: 4 to 13 days.
 Depth of flood: 2 ft. to 5 ft.
 Estate area flooded: 10,500 acres (approx.)
 Silt deposited: negligible.

- (iv) Inland Perak. Instances of flooding were reported from Taiping, Ipoh, Batu Gajah, Tapah and the Slim River. The flooding occurred in ravines and, though small areas were involved, considerable depths of flood water were encountered. The floods were the highest recorded.

Duration of flood: 8 to 19 days.
 Depth of flood: 2 ft. to 5 ft. In Taiping 20 ft. to 30 ft. was recorded in ravines.
 Estate area flooded: 1,000 acres (approx.)
 Silt deposited: 4 inches to 18 inches over about 100 acres.

- (v) Kuala Selangor. This district has floods annually about November; the present occurred in December and is the highest recorded.

Duration of flood: 8 to 21 days.
 Depth of flood: 2 or 3 inches up to 6 or 8 ft.
 Estate area flooded: 7,000 acres (approx.)
 Silt deposited: negligible.

- (vi) Muar River. The areas affected are in Negri Sembilan, Johore and Malacca. Flooding took place both on the upper reaches of the river and near its mouth. The general flood came, here as elsewhere, at the end of December, but it was followed by a further flood from mid-January to early in February. These floods surpassed all previous floods.

Duration of flood: 11 to 25 days (Dec.—Jan.)
 11 to 22 days (Jan.—Feb.)
 Depth of flood: 3 or 5 ft. to 8 or 10 ft.
 Estate area flooded: 2,500 acres (approx.)
 Silt deposited: negligible (2 to 3 inches on 100 acres).

- (vii) Temerloh. This area underwent unprecedented flooding. In some instances no floods have been previously recorded or flooding had occurred but not to any unusual extent. Roads and railways were destroyed in many places and some months must still elapse before communications can be restored.

Duration of flood: 25 to 40 days.
 Depth of flood: 15 ft. to 50 ft.
 Estate area flooded: 1,800 acres (approx.)
 Silt deposited: 6 inches to 3 ft. over 400 acres.

- (viii) Kuantan. Unprecedented flooding occurred here also. The road from Kuala Lipis to Kuantan is still interrupted.
 Duration of flood: 3 floods in December, January and March, lasting 17, 3 and 4 days respectively.
 Depth of flood: December 2 ft. to 60 ft., January and March 4 ft. to 30 ft.
 Estate area flooded: December 3,000 acres, January and March 2,300 acres.

Silt deposited: 6 inches to 16 ft. Average $4\frac{1}{2}$ to 5 ft. over 3,000 acres. Washed away by subsequent rain to 1—6 ft. over 2,000 acres.

(ix) Kelantan. Records from Kelantan are still incomplete. In one instance all estate records were lost in the flood. The railway line, I understand, has disappeared in places and will require to be built anew. The floods in Kelantan also were unprecedented.

Duration of flood: 7 to 15 days.

Depth of flood: 10 ft. to 50 ft.

Estate area flooded: 900 acres.

Silt deposited: 8 inches to 3 ft. over 400 acres.

DISEASES AND PESTS.

Contrary to expectation there is, it is generally agreed, no marked increase in the incidence of disease following the floods. In particular, both Mouldy Rot and Pink Disease have been feared, but only one outbreak of the former has been reported and the latter has occurred more severely usually where infection existed before the floods came.

A few instances of alleged Claret Canker on the submerged portions of the trees were reported from Pahang and Kelantan, but in one of these, it was suggested, that the damage may have been due to logs being washed against the trees by the flood water. It is unlikely that these are authentic cases of Claret Canker, but the material will be examined by an officer of this Institute on his forthcoming visit to these States.

Black stripe, which had also been feared, was recorded in a severe form in two instances only.

Ustulina developed on bruised stems on one estate where trees in falling had damaged neighbouring trees.

Root diseases due to *Fomes semitostus* and *Sphaerostilbe* were reported from two estates.

Boring beetles have been recorded in three cases but these insects probably attacked trees which were already diseased or had suffered damage from some other cause.

White ants were reported on two estates as having increased after the floods, while on another estate it is stated that the floods appear to have exterminated them.

MECHANICAL AND PHYSIOLOGICAL DAMAGE.

By far the most serious damage was that caused by windstorms on the flooded fields, which resulted in trees being blown over in Perak, Pahang, Selangor and Johore. A total of over 27,400 trees

were blown down, the majority being on one estate where a severe cyclonic wind was experienced. In addition a total of 3,500 trees are reported as damaged by wind in different parts of the country. A case of root damage caused by swaying of the trees under heavy wind has been recorded and this was followed by a considerable drop in the yield per acre. These cyclonic windstorms are apparently the most serious menace to be feared in times of flood.

Many instances have occurred of splitting and cracking of the bark, accompanied by exudation of latex, on the submerged portions of the trees but it is generally agreed that the trees recover quickly.

Some decay of the bark on the tapping panels and in their vicinity occurred but this type of damage appears to have been not at all common.

A general feature of flooded areas has been a more or less heavy fall of green leaf, but here again recovery is rapid, and in one case the trees acquired a heavier foliage than they had before the flood.

YIELDS.

The effect of flooding in increasing yields from areas so flooded has been illustrated in a remarkable manner by the very complete figures supplied by a few estates in Perak and Selangor and receives support from the experience of other estates where figures have not been given.

It should be noted that some estates report a decrease in yield after flooding. An examination of these cases, however, shows that this decrease is in the monthly estate output over the flood period and it is thus attributable to loss of tapping days or it may be explained otherwise than as an effect of flooding on the trees. For example the decrease on one estate is attributed by the manager to the swaying of the trees under heavy winds whereby there was a considerable amount of root damage. As this estate had 3,000 trees blown down and 3,000 more broken by wind there is little reason to doubt this explanation.

In the majority of cases estates report no change in yield before and after the floods.

Where increases in yield from flooded fields are shown, they are based on detailed figures and therefore command respect. Seven estates record an increase of between 20% and 40% in the yield of latex from flooded fields after flooding. Four estates report that their experience is to the same effect. When trees are tapped after having been submerged, the latex, after each tapping, continues to flow for hours into the afternoon or even well into the night. The increased flow of latex is maintained for three weeks or a month during which period it gradually re-

turns to normal. One estate reports a low rubber content during this period. Another estate reports that following the heavy flow of latex the trees frequently develop brown bast.

The following notes on the rainfall of the flood period have kindly been prepared by Mr. S.G.G. Kelliher, the Meteorological Observer, F.M.S. of the Survey Department, Kuala Lumpur.

NOTES ON THE RAINFALL OF DECEMBER, 1926 AND JANUARY, 1927.

The Rainfall for December had been considerably below the normal until 17th when light rain occurred all over the Peninsula, except in Kelantan where heavy rain fell, 7.56 inches being recorded at Kuala Kelantan. Unfortunately there is a large stretch of country North of Kuala Lipis, and on the main range of mountains North of Cameron's Highlands where no records are taken, but it is probable that the heavy rains experienced in Kelantan on December 17th continued inland and across the main range in a South Easterly direction, and were the initial cause of the floods in Perak.

Moderate rainfall was generally experienced from December 18th to 22nd, except in the Kinta, Upper Perak, South Kedah, and Batang Padang districts, where heavy falls occurred.

December 23rd was a day of heavy rain, especially in Kelantan, Pahang, and along the Western side of the main range. December 24th and 25th were dry, except in Kelantan and Pahang where heavy rains continued.

December 26th to 29th will probably figure as the wettest period of which there are any records. Very heavy rain occurred all over the Peninsula. At Kuantan 20 inches were recorded on that day, and 54 inches on the 4 days 26th to 29th. At Freda Mine, Kemaman 51 inches were recorded on 5 days December 25th to 29th.

The rainfall was 200% above normal for December in Pahang and Kelantan and on the main range. About 100% over normal on the Western side of the main range, while on the Western coast it was practically normal or even below normal in places. In dealing with the question of floods however it is not the rainfall for the whole month that matters, but the period 17th to 31st.

Accustomed as we are to rain, usually local, and, though very heavy, generally of short duration, such a period of almost continuous rainfall has not been experienced for 30 years. Kuantan district was the storm centre, 70-75 inches being recorded in these 15 days. At 50 miles inland the amount recorded was approximately 50 inches, and by the time it had reached the main range, it had decreased to 25-30 inches. On the Western side of the Peninsula, though the rainfall was 100% above normal, the flood-

ing was entirely due to the heavy falls reaching the main range from the East coast and coming down the water sheds on the Western side.

Owing to the narrowness of the peninsula farther North the rains swept right over from East to West coast, thus accounting for the floods in South Kedah, Selama, and Larut districts, whereas farther South the heavy rains did not extend beyond the main mountain range. The South parts of Negri Sembilan, with Malacca, and Western side of Johore had also only comparatively light falls.

The rainfall in January 1927 was also considerably above normal causing a continuance of the floods on a lesser scale.

G. BRYCE,
Director.

SUMMARY OF VISITS PAID TO ESTATES.

November 1926—December 1928.

	No. of Estates Visited.	No. of Visits Paid.
Director ...	23	23
Botanical Division ...	76	112
Chemical Division ...	30	31
Pathological Division ...	61	67
Soils Division ...	60	71
Total.	250	304

N.B.—A Field Survey of Small Holdings has been inaugurated.

EXPERIMENTS.

November 1926—December 1928.

	No. of Estates.
Botanical Division ...	4
Pathological Division ...	2
Soils Division ...	36

STATISTICS OF LECTURES DELIVERED.

November 1926—December 1928.

Director	...	...	...	3
Botanical Division	...	...	...	18
Chemical Division	...	...	...	8
Pathological Division	...	...	...	8
Soils Division	...	...	...	12
				—
Total				49
				—

The above lectures were delivered before the following bodies:—

PLANTING ASSOCIATION.

Asiatic Planters' Association of Malaya.
 Batang Padang.
 Central Perak.
 Johore.
 Kajang.
 Kedah.
 Kelantan.
 Malacca.
 Muar.

INCORPORATED SOCIETY OF PLANTERS.

Annual Conference, Penang.
 Annual Conference, Port Dickson.
 Batang Padang Branch.
 Kajang Branch.
 Klang Branch.
 Kuala Selangor Branch.
 Nilai Branch.
 Province Wellesley Branch.
 Sitiawan Branch.
 Tanjong Malim Branch.
 Teluk Anson Branch.

MISCELLANEOUS.

American Visitors.
 Muar Civil Service Club.
 Sepang Club.

ANALYSIS OF CORRESPONDENCE.

ESTATE ENQUIRIES AND PLANTING PROBLEMS ONLY.

November 1926—December 1928.

Subjects.	No. of letters dealt with.
Anti-Oxidants of latex	4
Anti-Coagulants of latex	28
Machinery of Rubber Manufacture	7
Vulcanisation of Rubber	6
Rubber Seed Oil	1
Crepe	82
Slab Rubber	9
Crepe Lower Grades	17
Coagulants	55
Rubber Preparation	3
Latex	85
Latex Preservation	13
Latex Concentration	4
Latex—Instruments for determining dry rubber content ...	54
Coagulating Tanks and Pans	9
Sole Crepe	41
Smoked Sheet	503
Smoke Houses	10
Air-dried Sheet	5
Water	27
Abnormal Growths on Hevea	1
Injury by External Agents	254
Fungus Diseases of Rubber	275
Brown Bast	160
Cover Plants	88
Epiphytes of Rubber	7
Fungicides	14
Tree Operations	16
Die-back	15
Re-planting	8
Resistance and Immunity	2
Seed-bed and Nursery Diseases	7
Thinning	3
Weed Suppression	2
Budgraft Diseases	10
Cultivation	14
Manuring	384
Soil Conservation	1
Drainage	34
Budding—Estate Enquiries	319
Estate Isolation Areas	23
Earliest Introduced Rubber Trees	12

Tapping	...	...	...	...	...	27
Seed Selection	...	...	...	...	...	2
Catch Crops	...	...	...	...	...	2
Fertilizers	...	...	...	...	...	15
Soil Samples	...	...	...	...	...	96
Water Supply	...	...	...	...	...	4
Electroculture	...	...	...	...	...	3
Statistics of Yield	...	...	...	...	...	4
Experimental Areas of Mature Rubber	...	...	...	...	...	1
Correspondence with Individuals	...	...	...	...	...	53
Methods of Packing Budwood for Transport	...	...	...	...	...	2
Latex Vessel Rings	...	...	...	...	...	16
Planting	...	...	...	...	...	8
Budding—General	...	...	...	...	...	62
Fertilisation of Hevea	...	...	...	...	...	2
Total						2,909

ANNUAL REPORT 1928.

Including Initial Period beginning June, 1927.

BOTANICAL DIVISION.

I. INVESTIGATION OF VARIATION IN *HEVEA BRASILIENSIS*.

In order to be in a position to investigate the variation in *Hevea brasiliensis* from tree to tree, type to type and strain to strain, it has been necessary first to determine by biometrical methods the amount of variation in a single tree. It should be emphasised here that hardly any data are available on the genetics of *Hevea* and, so far as can be ascertained, little fundamental work of an analytical character has been done. On this account it was necessary to start at the very beginning but, nevertheless, useful results have already been obtained. Attention has first been directed to the leaf and seed, as the two most obvious and easily measured organs, and an examination was made of these in a number of trees, including some of the oldest trees in Malaya and also in 4 to 5 year old budded trees on two fairly widely separated estates. This work was started by Mr. Mann and the Head of Division in September 1927, on certain of the oldest trees in Malaya, and handed over to Mr. Morris on his arrival in November, 1927.

Two leaf indexes have been found to be of use, namely, the ratio of the length to the greatest width (L/B) and the ratio of the length to that distance from the tip at which the greatest width occurs (L/E). It has been shown that the average value of either of these ratios, determined from at least 25 leaves picked by chance from different shoots of a tree, gives for this particular tree a characteristic index which is easily calculated and applied.

In the case of the seed, Mr. Morris has found that the two ratios of length to breadth (L/B) and length to greatest thickness (L/T) are, within a narrow range, characteristic for a given tree. These ratios are very useful for establishing differences but, as the indication they give of shape is insufficient, they need still to be reinforced by eye judgment for actual proof of similarity. Because of slight variations, it has been found necessary to examine the seeds from at least three fruits of any one tree in order to obtain a characteristic sample.

A series of determinations of the above ratios for leaf and seed has shown that, within a clone, the tree to tree variation is so slight as to make the ratios characteristic for a particular clone

A start has been made with the examination of leaves and seed from an area for which satisfactory yield records are available, the object being the discovery, if such exist, of different types of trees with specific yields. The more immediate value, however, of such botanical measurements lies in the identification and sorting out of clones in budded areas where mixing has occurred or where the planting records have been lost. They are also valuable in detecting "rogues" amongst budded trees where mistakes have been made despite careful records of planting. For example, on the Pilmoor budded area "rogues" have been discovered by these methods, in one case greatly to the improvement of the tapping record of a clone where mixing had inadvertently occurred.

In order to investigate not only the botanical variations but also the yield variations in the offspring from single trees, groups of about 100 seedlings from single trees have been planted out at the Experiment Station. In connection with work on selected seed it is very important that such a piece of fundamental knowledge should be known. This experiment will also throw light on the extent to which the yield-capacity of the female parent is transmitted to the offspring.

Other work on variation has not yet made sufficient progress for any positive statement to be made on it. For example, the method first published by Dr. E. A. Hauser, showing the possibility of identification of individual trees or clones from the character of their latex particles, appeared of the greatest importance and called for immediate test. In this connection it was necessary first to work out a method for the microscopical examination and photography of the latex particles. Mr. Gunnery found that by coating microscope slides with a dilute gelatin solution containing a suspension of latex, allowing this film to dry, treating it with formalin and finally staining with an aniline dye, it was possible to obtain a brilliant negative picture on a coloured ground, which allowed not only examination with the highest powers of the microscope but also photography of the particles. Further experiment is required, however, on fixing the correct dilution of both latex and gelatin.

A piece of work undertaken by Mr. Kaimal has given results of great interest and importance. This consists of an investigation of the diagnostic value of the latex vessel system in the embryo of the seed. Even at this stage, a well-defined latex vessel system is present in the embryo and there is much variation in the degree of occurrence and general construction of these vessels in different fruits, whether of the same mother tree or of different trees or clones. Consequently the embryos can be divided into three classes according to the arrangement and number of the

latex vessels, but the number appears to be the most significant factor. The investigation has, up to date, been confined to the region of the hypocotyl and the three classes are as follows:—

- (1) A complete ring of latex vessels is present in the hypocotyl, the vessels being closely aggregated.
- (2) This is an intermediate class where the latex vessel ring is not complete but split up into 6 groups of vessels corresponding to the 6 primary vascular strands while the groups are situated close to one another.
- (3) In this class the number of latex vessels is fewer and the 6 groups are arranged widely apart.

From this work it may be possible to decide whether these characters can be used as a basis for selection work and the research is proceeding towards this end.

II. THE SELECTION OF AND BREEDING OF HIGH YIELDING TREES.

Steps were taken as early as possible to secure seed from trees which might be supposed to possess high yielding characters. In 1927 and again in 1928 seed was obtained, through the Director of Agriculture, Ceylon, from the first generation offspring of the famous high yielding tree, No. 2 Heneratgoda. Seed was also collected from as many as possible of the earliest Malayan trees including those near the Residency at Kuala Kangsar, the Museum, Taiping, and the District Officer's Quarters at Parit Buntar. Other seed was taken from old trees on Inch Kenneth Estate and from Mr. Alma Baker's estate at Batu Gajah. The seedlings from these ancestral Malayan trees have been established in a special field at the Experiment Station.

In addition, seedlings from the budded seed gardens of the Anglo-Dutch Plantations, Java, have been raised from seeds very kindly presented by this undertaking. This seed was received very carefully packed and strikingly high germination percentages were obtained.

Experiments and observations on the pollination and fruiting of *Hevea* have been made on the $3\frac{1}{2}$ to 4 year old budded trees on Pilmoor Estate, Selangor. These were made possible by facilities kindly afforded by the Pilmoor Rubber Company and our indebtedness to them is very considerable. The main object of this work was to explore the position and develop a satisfactory technique. Work was carried out by Mr. Morris during the two flowering seasons of 1928, namely, May-June and August-September.

The results of the first season's work have been described in the Quarterly Journal of the Rubber Research Institute for January, 1929, and need only be summarised here.

437 female flowers of 5 different clones were pollinated from male flowers of other clones, the result being that 3 fruits were obtained. From these 8 seeds were germinated and the seedlings safely planted out on the Experiment Station along with ordinary seedlings from the same trees for purposes of comparison.

From 410 female flowers pollinated from male flowers of the same clone not a single fruit formed.

In the second flowering season 1,248 female flowers were cross-pollinated. These flowers were taken in 19 combinations from 7 good clones and 91 fruit were still on the trees at the end of the year. These gave promise of about 7 per cent. of successes but some of the fruits appeared to be abnormally small. When finally harvested in February-March, 1929, 274 seeds were obtained from which 205 germinated. Four deaths occurred but finally 201 seedlings were successfully planted out on the Experiment Station.

Fifteen of the nineteen crosses gave fruit, the percentage of success varying from 0 to 20. This agrees closely with the published results obtained by Heusser of the A.V.R.O.S. Experiment Station who first demonstrated the unequal fertility of different crosses. The results also showed that reciprocal crosses may be by no means equally successful.

Once again all the self-pollinations of 195 flowers failed.

Thus during the year 1928 2,290 flowers were pollinated. From 1,685 crosses 91 fruit or 5.4 per cent. successes were obtained but none of the 605 self-pollinated flowers set fruit at all. It is very gratifying to be able to record that the result of the first season's work is the production of no less than 201 seedling crosses for investigation on the Experiment Station.

From observations of the stage of opening of the female flower and of the time of day when pollination was carried out it has been found that the success increases markedly from morning to afternoon. Flowers were pollinated at all stages but pollination was most successful with newly opened flowers. Success was greatest on the afternoon of the day of opening and much less on the afternoon of the day before and on the morning after opening. On the second day the success, though less, increased from morning to afternoon and on the second day after opening a few successes were obtained in the morning but not in the afternoon.

If these results are confirmed in 1929 they may prove to be of considerable value in working out a method suitable for practical use. A much greater chance of success should also accrue from much less labour in pollinating.

III. VEGETATIVE PROPAGATION OF HEVEA.

This subject has formed the most important section of the plant physiological research and has entailed a very considerable

amount of field and advisory work. Most of this has been carried out by Mr. C. E. T. Mann, the Plant Physiologist, with the assistance of Mr. F. Billington, Field Officer, and the Head of Division. The work has fallen into three main sections:—

A. Field Experiments.

B. An Intensive Laboratory Study of the Budding Operation.

C. Test Tappings of Mature Budded Trees.

A. The aims in this section as well as in the following one were (a) to develop a method of budding which could be readily taught to Tamil coolies,

(b) to gain further information on the most suitable conditions for the operation, and

(c) to obtain material for a Laboratory study of the process of union of stock and scion in order that the fundamental knowledge gained in such a study should be available for the diagnosis of failures and unsatisfactory results generally.

Experimental work was begun in August, 1927. A preliminary examination of bud structure and the behaviour of the cambium in seedlings and normally vigorous branches was first made and in October 1927 experimental work on the technique of the operation was begun.

We are greatly indebted to several estates mentioned below and especially to Seafeld and Pilmoor Estates for facilities kindly provided during the course of this work. An account of the results obtained on the latter estate has been published by Mr. Mann in the Quarterly Journal of the R.R.I. for January, 1929. These showed clearly that budding is best carried out during the more rainy periods, namely, late March to May and October to January, the latter period being preferable. Dry periods following closely on the operation always greatly reduce the percentage of success.

These seasonal influences are more marked under field conditions than in nurseries.

During the progress of these experiments modifications and improvements in technique were taught to the Institute conductors who have been employed in training coolies on numerous estates in all parts of the Peninsula.

B. The laboratory study of the process by which the bud becomes united to the stock has established the following points:—

(1) Successful union depends primarily on the condition of the cambium of both budwood and stock. In both, the cambium must be in an active condition showing vigorous cell division. "Non-stripping" of the stock bark or of the bud-patch is due to a resting condition of the cambium tissue.

(2) The first stages of union are accomplished by the development of a wood callus produced from the exposed surface of the wood of the stock as well as on the inner surface of the bud patch.

(3) Most of the development takes place from the exposed ends of the medullary rays of the wood of the stock but the cambial cells may contribute also to this early callus development. The interlocking of the medullary ray cells in the earliest stages forms an irregular parenchymatous tissue which may be completely established in 7 days.

(4) Between the edges of the bud patch and the bark of the stock a normal wound callus is formed from the wood of the stock. Approximately three weeks after budding a vascular cambium is differentiated in this tissue which definitely becomes connected with the cambium of both the patch and the stock. The repair of this cambium ring is normally complete about 4 weeks from the date of the budding operation.

(5) A microscopical study of the later stages has indicated that an intimate connection between the stock tissues and the cone of cambium tissue round the medullary plug of the bud is essential. Failure to form this connection is probably one of the causes of "non-sprouting" of apparently successful buddings. This work is being continued, a further series of buddings having been made to provide material for a closer study of the earliest stages of the union. This portion of the work is being carried out jointly by Mr. Mann and Mr. Gunnery.

(6) A first examination has been made of the union of scion and stock in the later stages, two months to 2½ years from budding. A series of permanent preparations illustrating these stages has been made.

In addition to the laboratory work field trials have been started in a number of cases.

(1) On the Experiment Station a large scale field experiment has been planned to test the relative value under uniform conditions of the proved high yielding clones which have been most widely used in Malaya. For this experiment the necessary nursery material has already been put down.

(2) Pilmoor Estate.—A field budding experiment on an area of 50 acres has been carried out with material from 5 promising new clones which have been discovered during the progress of test tapping experiments on the estate. Some results of this have been described by Mr. Mann in the Quarterly Journal of the R.R.I. for January, 1929.

(3) Changkat Kinding Estate, Perak.—An area of 26 acres of older stumps has been budded with clones A 44 and A.V.R.O.S. 50 and 152. As this area shows wide variation in soil type and

growth of the trees it is hoped that eventually it will be possible to compare the performance of buddings and seedlings under very varied conditions.

(4) Lubok Estate, Kedah.—A field of 10 acres has been budded from 16 high-yielding estate trees with a view to the establishment of new clones.

(5) Gunong Kroh Estate, Perak.—Buddings of clones A 44, B 84 and A.V.R.O.S. 50 have been established in (a) a small replanted area in older rubber, (b) reclaimed swamp land. The object of this experiment is to test the performance of clones under the special conditions prevailing.

(6) Seafeld Estate.—Buddings of clones A 44 and B 34 have been established together with Sumatran and other Malayan clones for the purpose of later comparative tests.

Advisory Work.—A large volume of this work has been carried out in relation to budding, the greater portion having been of the nature of routine work. Written enquiries have been dealt with from a total of 58 estates where budding work is in progress. The subjects covered by these enquiries include:—

- (a) General Information on Budding Technique.
- (b) Suitable Stocks of Budwood.
- (c) Pollarding of High Yielding Trees for Budwood.
- (d) The Season for Budding.
- (e) The Relative Value of Proved Clones.
- (f) Causes of Failure in Budding Operations.

To deal adequately with many of these enquiries visits to many of the estates have been necessary. In this connection upwards of 150 visits have been made to estates where budding was in progress and many of these have entailed a stay of several days on the estate.

The scheme for training small gangs of coolies on estates has been continued and further developed. Conductors were sent out to 35 estates in order to train coolies and give assistance in the organisation and early stages of field work. The usual training period has been one week with a second visit paid 2 weeks later in order to examine the results of test work and select the best men for later operations. There is no doubt that, as a result, the standard of budding throughout Malaya has in general been raised considerably but further efforts are required in order to diminish the number of failures of successful buddings after opening and of budded stumps after being transplanted from the nursery to the field.

Laboratory investigations have also been carried out by Mr. Mann on material sent in by estates, for example, failures, defective budwood, and the effects of using impure samples of budding wax. In 1928 the anatomical investigation of the union

process had progressed far enough to make it unnecessary in most cases to examine the samples and specimens received. Six special cases of failure and defective budding were, however, examined.

In addition to the above work two lectures were given by Mr. Mann in 1928 and 14 by the Head of Division. Exhibits of work on budding were prepared for, and demonstrations of budding were given at three agricultural shows, and also at the I.S.P. Conference at Port Dickson and the Annual Meeting of the Council of the A.P.A.M.

C. TEST TAPPING OF MATURE BUDDED AREAS.

Test tapping was carried out by Mr. Kaimal in 1928 on 12 acres of buddings on Pilmoor Estate, Selangor. 21 clones were available for tests, the trees having been budded between December 1923 and June 1924 and planted out as stumps September to December 1924. At the beginning of 1928, therefore, the trees were $3\frac{1}{2}$ to 4 years old from the time of budding and 3 to $3\frac{1}{2}$ years old from the date of transplanting.

It was decided to begin test tapping of all trees which had a girth of more than 15 inches at 40 inches from the union. As the trees were so young it was necessary to adopt a conservative tapping scheme, which, without injuring or retarding the buddings, would yet give a reliable indication of the yielding capacity of the trees throughout the year. In no sense of the word, therefore, was this a commercial tapping test. It was decided that the main scheme should be alternate daily in alternate months at a height of 20 inches from the union, but where a clone had a large enough number of trees half should be tapped alternate daily and half $\frac{1}{3}$ rd daily at the same height. In all cases a standard 8 inches left spiral cut with an angle of 30° was employed. Bark consumption was limited to one inch per month and all trees were tapped by the same tapper. The latex was coagulated in the cup after each tapping, the biscuits being collected weekly, creped one by one in the factory, then dried and weighed in the laboratory.

14 clones out of 21 were tapped but only the results for five of these are of immediate interest, namely, clones A 44, B 84, B 58 and B 50. The results for the third daily tapping followed closely and proportionately those for the alternate daily system so the latter is the only one referred to here.

Probably much more latex could have been obtained from the trees by a more severe tapping system but the first year's results were sufficient to show that the yields of A 44 and B 84 were at least as good as those of the best A.V.R.O.S. clones. These results are being amply confirmed by the tapping figures for 1929 which are the result of a commercial daily alternate monthly

system, for, in this, the second year, the yields are very much greater than in 1928. Many interesting points have arisen during these tapping tests but these will be dealt with fully in a separate paper. The clone yields are not at all in the order of the respective mother tree yields; the mother tree of the best clone, A 44, was second in order of merit while the best mother tree, B 58, has produced the third best clone. The second best clone, B 84, came from the fourth best mother tree while the fourth best clone came from the 15th best mother tree. This points to the necessity for caution in relying on the vegetative characters of the mother tree as an indication of the probable value of the clone.

During the test tapping Mr. Billington has carried out periodic measurements of girth and bark thickness both of virgin and renewed bark. The latex vessel systems have also been investigated. The rate of renewal and the quality of the bark are excellent so that there are no grounds for misgivings in respect of either.

IV. PHYSIOLOGY OF LATEX PRODUCTION.

The tapping experiments on budded trees have given valuable data suggesting future lines of work on the fundamental question of latex production.

The behaviour of budded trees when tapped later than usual is of special interest. The volume of latex obtained is much reduced but there is a marked increase in the dry rubber content of the latex. Consequently the amount of dry rubber obtained is considerably higher than the volume measurements alone would indicate. This feature emphasises the importance of dry weight records as opposed to volume records of yield.

Further there is clearly a close connection between the yield at tapping and the physiological condition of the tree. The relation between transpiration and internal pressures (root pressure) and yield will be further investigated in the course of future tapping experiments.

In view of the paucity of information on this subject it was decided to make an intensive study of the seed and seedling with a view to elucidating the development of the latex vessel system from the start. Reference has already been made to the work on the seed.

During the course of this research it has been necessary to halt in several places in order to determine various elementary points in the general botany of the seed and seedling upon which data were not available. From this work several results of practical importance have emerged. For example, Mr. Kaimal, in his study of the germination process, found that freshly gathered seeds lose practically the whole of their contained moisture in

14 days. The rate of loss curve is steep at first for during the first three days no less than 50 per cent. is lost and most of the remaining moiety during the next 10 days. From the 14th to the 85th day hardly any further loss occurs.

The germination curve closely follows the curve for loss of water, showing clearly that, in order to obtain maximum germination, seeds should be freshly gathered and planted within three days. Mr. Kaimal has also shown, in preliminary experiments, that if the seeds can be prevented from losing water they retain almost unimpaired their germinating power. The treatments employed so far have been waxing the seeds, a method previously advocated by Spring, or maintaining them in a closed chamber in an atmosphere of high relative humidity.

Mr. Kaimal has also investigated the possibility of increasing the germination percentage by treatment of the seeds before sowing. The following methods have been tried:—

- (1) Puncturing 5 or 6 small holes in the seed coat.
- (2) Scraping off the external membranous skin of the seed.
- (3) Cutting off the operculum, that is the small circular patch which covers the tiny opening through which the primary root emerges on germination.
- (4) Removing the coat of the seed completely.

So far as increasing the rapidity and percentage of germination, methods 1, 3 and 4 are almost equally good, but, taking everything into consideration, No. 3 is the most practical method and can be carried out by coolies after a little instruction. This method has been adopted in the Botanical Division as a standard practice with all valuable seed.

During the establishment of nurseries Mr. Kaimal has recorded for the first time results of great interest and value from observations and measurements of the growth activities of seedlings, and has demonstrated a most remarkable periodicity in the growth of each internode or storey. During this growth three phases are shown in each period:

- (1) On germination the shoot pushes vertically upwards to reach a maximum height, the rate of growth being low for the first 2 or 3 days, thereafter increasing rapidly until it tails off during the 2 or 3 days before reaching maximum height.
- (2) From this point all the growth energy of the seedling goes into the development of the leaves at the top of the storey. The leaf stalks show the same kind of growth as the shoot, as also do the leaves, except that the latter carry on 3 or 4 days longer than the leaf stalks before ceasing to grow. Growth in size both of stalk and leaf then stops.

- (3) The next work of the seedling is to raise the leaves from the hanging position to the horizontal. When this is completed, and not before, the resting terminal bud begins to grow out again and repeats this cycle for the next storey. Corresponding colour changes of the leaves characterise the second and third phases.

The period of a complete cycle of three phases is, on an average, about 36 days. This practically comprises two periods of about 18 days each during the first of which extension growth is carried out and leaf development during the second.

Growth periods and curves are alike for different seedlings while the periodicity is affected by weather conditions only to a very small extent. These periods are doubtless minor periods within major periods characteristic of the tree and occurring from wintering to wintering. It is highly probable that the investigation when extended to adult trees will throw some light on the problem of the production of latex. Mr. Mann has already demonstrated in striking fashion the practical bearing of these observations on successful budding. (*Quarterly Journal R.R.I.*, January, 1929). He has shown that the percentage of success is greatest during the first phase of vigorous extension growth and much less during the time when the terminal bud is resting.

This work has been extended by Mr. Kaimal and the Head of the Division to include an investigation of growth relations in the leaves of seedlings and preliminary results of considerable importance have been obtained.

In each normal whorl of leaves on a seedling there is a direct proportional or linear relation between the petioles which decrease regularly in size from the bottom of the whorl upwards. A similar proportionality is characteristic of the leaflets so that given the position and size of any two petioles or leaflets the size of any of the remainder can be calculated without reference to the seedling. This regularity is disturbed only in relatively few cases due to such external causes as insect attack or bending of the seedling. In the same way the buds situated in the axils of the leaves decrease regularly in strength from the bottom of the whorl to the top.

A microscopical study of the petioles in section has shown the existence in correspondingly situated cells of a similar regularly decreasing size gradient from the bottom leaf to the top one. This applies to the cells of all the tissue systems, namely, pith, wood, cortex and epidermis.

In other words each petiole has its own characteristic cell-size. The cells of the lowest are greater than the correspondingly situated cells of the second which will be greater than those of

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26TH JULY, 1929.

At the end of the Annual Report of the Botanical Division it should be recorded that the programme of experiments in relation to tapping was worked out by the Head of the Division in consultation with his staff; the work alluded to in the text was inaugurated by Mr. Billington and continued by Mr. Kaimal.

It should also be recorded as an addition to the Report that a further series of tapping experiments comprising some 15,000 records of yield were taken at Pilmoor Estate by Mr. Mann and Dr. Edgar Rhodes. The experiments were carried out during the period June—December 1928; during the first month the recording was undertaken jointly by Messrs. Mann and Rhodes, it was subsequently continued by Dr. Rhodes. The results of the experiments have been summarised by Dr. Rhodes.

It should be understood that the statement on page 42 of the Report, devoted to tapping experiments, is based on the results of all such experiments undertaken.

the third and so on to the uppermost petiole which has the smallest cells of all.

This regular size gradient is a product of the vertical growth response of the seedling to the tropical sun, the phyllotaxy of the leaves and the internal rhythm factors responsible for the growth periods described above.

In the branching tree these regular growth gradients are disturbed by the inclination of the branches at an angle to the vertical. In consequence the leaves on the lower side of the branch tend to be larger than normal while those on the upper side tend to be abnormally small. These results disclose a factor which has never been taken into account in advocating the employment of petiole cell measurements as a means of seedling selection.

V. COVER CROPS.

Up to the time of reporting the amount of experimental work on cover crops has only been small. Advice has been given in 20 cases and identifications made of unknown native plants considered by estates to have the properties of good natural covers. Amongst those plants which have been sent in on more than one occasion are *Oldenlandia dichotoma*, *Hydrocotyle Asiatica*, *Spermacoce species*, *Solanum biflorum*, *Desmodium trifoliastrium*, *Desmodium ovalifolium*.

To carry out identification speedily a herbarium collection has been started.

On the Experiment Station attempts have been made in a new clearing to establish two small species of *Desmodium*, namely, *D. heterophyllum* and *D. triflorum*.

VI. GENERAL.

It is a pleasure to record an appreciation of the enthusiasm and devotion to work of the subordinate staff, Malay and Indian.

F. SUMMERS,

Head of Botanical Division.

27th April, 1929.

ANNUAL REPORT 1928.

Including Initial Period beginning November, 1926.

CHEMICAL DIVISION.

This first annual report includes investigations carried out since the writer was appointed on November 1st, 1926, and thus covers a period of approximately two years. Certain observations and conclusions based on the results of the principal investigations are included in the report, for the benefit of planters and others interested in the problems which are dealt with.

STAFF.

I proceeded on service leave on 30th June, 1928, until the end of the year. I left Kuala Lumpur, however, on the 15th June in order to visit Ceylon on duty during the voyage to England. Mr. R. G. Fullerton acted as Head of Division during my absence.

The subordinate staff has had to be trained before becoming of much assistance.

I have to express my thanks to Mr. Fullerton for his valuable assistance in connection with a number of the investigations described in this report.

ORGANISATION WORK.

Until the new wing of the Institute was completed and ready for occupation in December, 1927, work was carried out under great difficulty in two small rooms in the main building which were not properly equipped until about the middle of 1927.

No suitable water, steam or gas supplies were available until early in 1928 and no real research investigations could be carried out till the new laboratory was completed and equipped.

Much time, however, was spent in connection with the supervision of alterations and fittings of the various laboratories and the fittings and equipment of the new wing, the installation of the experimental vulcanisation plant taken over from the Department of Agriculture, S.S. and F.M.S., the equipping of an experimental factory for the preparation of sheet rubber, erection of smokehouse, experimental drying room, hot-air drying chamber for rubber, erection of gas plant, boiler for steam supply, water supply and other equipment.

The staff was also fully employed in the time available in answering enquiries, writing reports on numerous samples of defective rubber received from estates and visiting estates in connection with various aspects of factory practice.

The Chemical Laboratory in the new wing was completed and fully equipped with water, steam and gas in January 1928. The experimental smokehouse, battery of sheeting machines and drying room were completed about the same time, when it became possible to commence investigations on experimental samples.

The design and equipment of the new laboratory have proved very suitable while the supplies of steam, water and gas are now satisfactory, various early difficulties having been overcome. The "Unit" system of laboratory benches, which has been adopted, is also proving adequate and convenient.

In view of the difficulties met with in the tropics the equipment of the laboratory has been carried out expeditiously.

PROGRAMME OF WORK.

At the request of the Director, a programme of work was drawn up for submission to the London Advisory Committee. This programme included problems requiring investigation over many years and also a separate programme which included the more urgent problems for investigation during the next few years.

It was realised that it might not be possible to adhere closely to such a programme on account of the numerous enquiries received from estates and other problems which might arise from time to time. Satisfactory progress has, however, been made in several directions. This is shown later in the report in a summary of the results obtained in connection with investigations on moulds in smoked and air-dried sheet, "spot" disease in crepe, "white streak" in smoked sheet, and the concentration of latex. Three of the above investigations are included in the immediate programme of work.

ADVISORY WORK.

The large amount of advisory work, which comprises chiefly the writing of reports to managers of estates, agency houses, etc., in connection with defects in rubber, the examination of various chemicals, water and latex, factory procedure, smoke-houses, factory machinery and equipment is shown in the analysis of this work given below. In many instances several letters and reports have been sent to the same enquirer in connection with numerous points which have arisen.

Much valuable time has been saved in connection with visits to estates by the issue of a Questionnaire on methods of

preparation. The replies to this Questionnaire have frequently enabled advice to be given by letter thus avoiding the expense and time involved by a visit to the estate concerned.

A satisfactory system of filing has also been adopted which enables easy reference to be made to enquiries of a similar nature.

ANALYSIS OF REPORTS.

The following table includes all the enquiries received from estate managers and other sources up to December 31st, 1928, on which reports have been prepared and despatched:—

Sodium bisulphite	...	4
Anti-coagulants (Sodium sulphite, sodium carbonate, ammonia and formalin)	...	27
Coagulants (Acetic acid, formic acid, sodium silicofluoride, pyroligneous acid and alum)	...	43
Factory machinery and equipment	...	14
Vulcanising machinery and testing apparatus	...	11
Rubber seed oil	...	6
Rubber oil	...	6
Slab rubber	...	11
Crepe rubber ("Spot" disease and other defects)	..	56
Latex (204 samples for dry rubber content, 2 samples for sodium chloride content, 1 sample for ammonia content, 72 samples of dry rubber for weight)	...	279
Latex preservation	...	23
Latex concentration	...	5
Metrolacs etc. (Testing and adjustment)	...	38
Latex (Methods of determining dry rubber content)	...	9
Coagulating tanks and pans	...	15
Sole crepe	...	26
Smoked sheet, Bubbles	...	56
Smoked sheet, Moulds	...	26
Smoked sheet, Use of para-nitrophenol and other fungicides	...	173
Smoked sheet, "Rust"	...	32
Smoked sheet, Miscellaneous defects and general	...	48
Smoke houses and fuel consumption	...	16
Air-dried sheet	...	5
Water	...	46
Patents	...	9
Miscellaneous	...	11

With reference to the above analysis of enquiries, in many cases these involved the examination of the strength and quality

of the chemical received (coagulants, anti-coagulants, etc.), the examination of all the water samples, the determination of the dry rubber content of all the latex samples, the estimation of sodium chloride in samples of preserved latex contaminated with seawater, the ammonia content of preserved latex, the testing and adjustment of the metrolacs, and a large number of tests for mould development in samples of sheet rubber received from various estates.

Moulds in Sheet.—The chief feature of the enquiries received is the number concerned with moulds in smoked sheet and the application of para-nitrophenol. This is due principally to the storage of rubber on estates after the announcement early in the year of the cessation of restriction of crop. The question of mould development is also becoming more prominent on account of modern methods of smoke-drying.

Bubbles.—The number of enquiries on bubbles is also fairly large. It does not appear to be realised that bubbles are not easy to eliminate, especially during the wintering season and after rain the previous night, since fermentation of a medium like latex, as in the case of milk, is somewhat erratic or irregular.

Other Defects.—The other samples of raw rubber examined for various defects do not call for any particular comment and reveal no new defect except in the case of white patches or spots in sole crepe which were discovered to be due to occlusion of air caused by inefficient lamination.

Latex.—In the examination of latex samples for dry rubber content, a large number of determinations were carried out in connection with (i) an experiment on deep and shallow tapping (ii) arbitration in connection with the local purchase and sale of latex.

Estate Factories.—Much advice has been given in reports on visits to estates in connection with the design and equipment of factories and smokehouses. The chief defects of a number of factories are lack of light and air. A good factory need be closed only with expanded metal behind the machines, while, if the coagulating tanks are placed at the side of the factory opposite the machines, this side need only be closed by means of expanded metal, provided the factory on this side has a verandah on which the receiving tanks are placed. This verandah provides sufficient shade for the coagulating tanks.

Smoke Houses.—In the case of smoke-houses, the chief defects are:—

- (1) The complete combustion of the wood fuel in open grates or on the floor, so that the smoke contains little or no antiseptic constituents such as creosote.
- (2) Insufficient roof ventilation to remove the hot damp air.

- (3) The use of exterior furnaces with long flues in which creosote and other valuable products of the "smoke" are condensed before reaching the smoking-chambers.
- (4) Excessive consumption of fuel, due primarily to the defect mentioned in (1).

Factory Procedure.—It is unfortunate but true that in Malaya the factory supervision is left generally in the hands of an untrained Asiatic factory conductor. Fortunately the modern method of bulking latex has reduced the variability of the raw product, but there is still considerable difference in factory practice between different estates.

It would appear from information available that the rubber prepared on large estates in the Netherlands East Indies is more uniform than that prepared on similar estates in Malaya, and this is due probably to the better factory supervision on estates in the former country.

Machinery.—There is also a great difference between the output of batteries of light sheeting machines, which are now generally used for the machining of sheet rubber. Estimates obtained from different estates vary from 200 lbs. to 550 lbs. of dry rubber per hour. This large difference is caused by variation in speed of rolls, width of coagulum, and thickness of sheets. A light battery consisting of three smooth machines and one marker, driven by a 3 H.P. prime mover, should be capable of the higher output given above. The rolls of the machines should be at least 20 inches wide.

Coagulating Tanks.—The problem of deeper tanks for coagulation, in order to produce wide sheets, is being investigated. The present tanks in use are usually not more than 11 inches deep, which means a depth of about 10 inches of latex, resulting in a narrow sheet.

SOILS AND MANURES.

Previous to the arrival of the Head of the Soils Division, all enquiries in connection with soils and manuring problems were dealt with by this Division. These enquiries, however, are not included in this report.

RESEARCH INVESTIGATIONS.

The principal research investigations, which were included in the Programme of Work as immediate problems have been carried out on the problems given below:—

- (1) Investigations on methods of prevention of development of moulds in sheet rubber.

- (2) Investigation on the possibilities of substituting for smoked sheet another type of first grade rubber or an imitation smoked sheet in which fuel other than wood is used as the source of heat for drying the rubber.
- (3) Concentration of latex and the effect of various protective colloids.

In addition the following problems have arisen and have been investigated:—

- (1) The development of “white or virgin streak” in smoked sheet.
- (2) The dry rubber content of latex from deep and shallow tapping cuts.
- (3) An investigation of the yellow colouring matter in latex separated by fractional coagulation in the preparation of sole crepe.

In connection with the investigation of the prevention of moulds in sheet rubber, the work has been extended to include air-dried sheet and “spot” disease in pale crepe which is also due to the growth of micro-organisms. The work on air-dried sheet is also of importance in connection with the possible substitution of this type of rubber for smoked sheet, on account of probable shortage of wood fuel.

The investigation of mould growth in smoked sheet due to damp storage has also extended to another defect of sheet rubber viz. the development of “white or virgin” streak in the interior of the sheet.

Observations and conclusions in connection with the above investigations are given below. The full details of technique and results obtained are being prepared for publication in the Quarterly Journal or in special Research Bulletins.

MOULDS IN SMOKED SHEET.

On account of the storage of rubber on estates after the announcement of the removal of restriction of output early in 1928, large numbers of enquiries were received in connection with the treatment of smoked sheet to prevent the development of moulds. This problem, however, had been under investigation previously and, as is well known, para-nitrophenol was introduced a few years ago and its use recommended by the scientific officers of the Rubber Growers' Association as a preventative against moulds. It was decided, therefore, to extend this investigation on the methods of application of para-nitrophenol, to include other possible fungicides which might be more suitable or economical and to ascertain the effect of the development of moulds on raw rubber. On account of the probable shortage of wood fuel for smoking the investigation was extended to the treatment of air-

dried sheet with para-nitrophenol with the object of marketing, at some future date, an air-dried sheet treated with a suitable fungicide as a substitute for smoked sheet.

Smoking Process.—This work has enabled us to make certain observations on modern methods of smoking raw rubber. At present the market fancy appears to require a fairly light-coloured smoked sheet. Such a sheet is produced by rapid "smoking" with an almost completely combusted wood fuel. The sheet is dried rapidly, usually in 7—10 days, but contains very little creosote or other antiseptic constituents from the "smoke" of the wood fuel used. A completely combusted wood fuel produces chiefly carbon dioxide and water vapour. On account of this practice of rapid drying with a completely combusted wood fuel, smoked sheet at the present time is exceedingly liable to develop moulds, if it absorbs moisture after removal from the smoke house.

The dark coloured smoked sheet marketed several years ago is more resistant to moulds, but if placed on the market at the present time would be described as "over-smoked" and would fetch a lower price.

This modern practice therefore necessitates in many cases the treatment of the latex, or the freshly machined sheet with some suitable fungicide, in order to reduce the tendency to mould development.

We have found that samples of smoked sheet prepared in our experimental smoke house, which are almost black, due to the amount of "smoke" absorbed, are very resistant to mould development. This confirms the statement made earlier that modern smoking practice on many estates is unsatisfactory, in so far as prevention of mould growth on the rubber is concerned.

Effect of Moulds.—With regard to the action of moulds on raw rubber the writer observed in 1916-1917 a loss of weight in "slab" crepe of 2 to 5 per cent. in a short period, due to the development of pigments produced by the growth of micro-organisms.

More recently de Vries has reported losses of weight in sheet rubber of about 20 per cent in 2 years and over 30 per cent in about $3\frac{1}{2}$ years.

Our investigations have shown that, when smoked or air-dried sheet is stored in a damp chamber, the weight increases usually up to about the 15th day due to the absorption of moisture and then begins to decrease as soon as the moulds appear on the surface. Losses of weight up to a maximum of 17.5 per cent have been found after storage for 14 months. These losses are also in the form of gaseous constituents, since the mouldy samples have not been washed or re-creped but only re-dried. The losses also indicate that the moulds are attacking the caoutchouc hydrocarbon.

No losses of nitrogen have so far been found in any of the samples, although the proteins in the rubber may have been converted into other nitrogenous compounds.

Application of Para-nitrophenol.—Para-nitrophenol has been found to be fairly efficient as a mould preventative. The method of application generally recommended is to soak the freshly machined sheet in a 0.1 per cent solution of the chemical. There are still a number of factors to be examined to determine the most satisfactory method of application.

Under the drastic conditions of damp storage adopted in carrying out tests on raw rubber for liability to mould growth, we have found that the development is delayed but not entirely prevented. This applies particularly to air-dried sheet.

If the fungicide is added to the latex, it is not known what proportion is adsorbed by the rubber globules and what proportion is removed in the serum when the coagulum is rolled. Secondly, when freshly machined sheet is soaked in a solution of a fungicide the sheet is still "sweating" and exuding serum, so that the absorption of the fungicide from the solution may be very low.

Probably the most satisfactory method would be to allow the sheet to drip in the open under shade for 2-3 hours and then to soak in the solution. This, however, involves further handling of the rubber and adds to the cost.

Use of Tri-chlor sodium phenate.—Tri-chlor sodium phenate has been investigated as a possible substitute for para-nitrophenol, since in pure culture it has been found to be from five to ten times as efficient as para-nitrophenol. Under the practical conditions, however, in which it has to be used, it is decomposed into trichlorophenol by very weak acids. This compound, very volatile at ordinary tropical shade temperatures, is much more so at the temperature of a smokehouse, so that the small proportion applied is rapidly lost. This accounts for the poor results obtained in practice in our investigations on this substance.

AIR-DRIED SHEET.

In order to avoid the complications involved by the effect of smoking in the treatment of sheet rubber with para-nitrophenol or other fungicides, it was considered advisable to carry out control investigations on air-dried sheet. This work is also of importance in connection with the possible substitution of this type of rubber for smoked sheet, on account of probable future shortage of wood fuel for smoking.

The development of moulds on these sheets has also resulted in losses of weight amounting to 17.8 per cent in one case during a storage period of eleven months.

Experiments on air-dried sheet treated with fungicides are being continued. In order, however, to dry sheet rubber in a reasonable time and thus avoid the construction of large drying rooms and the consequent retention of large quantities of rubber on the estate, some system of hot-air drying, using crude oil or local coal as fuel, will probably be essential. A hot-air chamber fitted with a steam coil, air inlet shafts and exhaust fan has been erected for investigation of this problem.

"SPOT" DISEASE IN CREPE.

The development of "spot" disease or pigmentation in pale crepe rubber stored in damp chambers, which is due to the growth of micro-organisms, has also resulted in losses of weight amounting in one case to 11.8 per cent during a storage period of about eleven months.

WHITE-STREAK IN SMOKED SHEET.

About five years ago, complaints were received from buyers in Singapore of a defect in smoked sheet described as "white streak" and considered to be due to "under-curing", i.e. incomplete drying and smoking, on the estate.

In the experiments on storage of smoked sheet in damp chambers, it was observed that this white streak developed in the interior of nearly all samples of smoked sheet after storage for 1-2 days with a moisture absorption of about 0.5 per cent in many cases. It is obvious therefore that the cause is not "undercuring" i.e. the sheet has been properly dried, but that the defect develops when the smoked sheet is stored subsequently in a damp place. Another interesting aspect of this development is that the inner white opaque layer does not contain more moisture than the outer transparent brown layers. The opacity of the inner layer is produced by absorption of moisture, and the white streak is probably due to the fact that, while quite dry, when removed from the smoke house, the inner layer has not absorbed the smoke constituents which cause the normal brown colour of the outer layers of the sheet.

This is confirmed by the fact that in the case of air-dried sheet or a very light coloured smoked sheet, the white opaque inner layer is very thick and in some cases the whole surface of the sheet becomes white and opaque.

THE CONCENTRATION OF LATEX BY EVAPORATION IN THE PRESENCE OF PROTECTIVE COLLOIDS AND ALKALIS.

In Malaya at the present time two methods of concentration of latex are being practised commercially. The first of these is that known as the Hauser process from its inventor (Dr. E. A. Hauser).

The product, which is marketed as Revertex, consists of a thick paste containing about 70 per cent of dry rubber or 73 per cent of total solids, and is prepared by the evaporation of latex in a heated horizontal rotating drum. The latex is maintained in a liquid state during evaporation by the previous addition of a protective colloid and a fixed alkali. The patent specification does not disclose the particular protective colloid and the fixed alkali which are employed.

It was decided to carry out an investigation on a number of protective colloids which might be suitable for the purpose, in the presence of a small amount of potash or soda.

The following substances were investigated:—gum acacia, gum tragacanth, egg albumen, casein, gelatin, peptone, saponin, potassium stearate, sodium oleate, sodium palmitate, sodium silicate, agar-agar and glue. Casein and tri-sodium-phosphate were also used but were found to be unsatisfactory. The latex, with the protective colloids and alkali added, was evaporated with constant stirring on a water bath.

The investigations showed that the most suitable protective colloids were the soaps—potassium stearate, sodium oleate and sodium palmitate—when used in the presence of small amounts of potassium hydroxide.

Less satisfactory results were obtained when the protective colloids were used in the presence of sodium hydroxide.

THE CENTRIFUGAL PROCESS OF CONCENTRATION OF LATEX.

The centrifugal process of concentration, in accordance with the Utermark patent, is also being carried out in Malaya. The latex is centrifuged in Alfa-Laval centrifuges rotated at about 8500 revolutions per minute. A small proportion of ammonia is added to the latex to maintain it in a fluid condition.

A complete separation of the latex into a fraction containing all the rubber globules and a clear serum containing only the water soluble constituents is not effected.

Samples of the concentrate (cream) and “skim” were found to contain respectively 57 per cent and 7 per cent of dry rubber. This concentrate differs from the concentrate prepared by evaporation. The latter contains all the serum constituents i.e. it is a “whole” rubber latex, while the former contains only a portion of the serum constituents.

THE DRY RUBBER CONTENT OF LATEX FROM DEEP AND SHALLOW TAPPING.

On two adjoining coastal estates belonging to the same company, from which latex is being sold, the manager of the estates

observed that the latex from one estate invariably gave a higher dry rubber content than the latex from the other estate and considered that this could only be explained by the depth of the tapping, the estate with deeper tapping giving latex with a lower dry rubber content and the estate with shallower tapping giving a latex with a higher dry rubber content. In order to test this, samples of latex from both estates, from deep and shallow tapping were examined fortnightly over a period of one year.

The results confirmed the opinion of the manager. The dry rubber content of the latex from both estates from shallow tapping was invariably from 1 to 3 per cent higher than that of the latex from deep tapping.

Apart from this, however, in the case of the deep and shallow tapping experiments on both estates, the latex on one estate has a lower dry rubber content than that on the other estate, for which no explanation is offered.

THE YELLOW PIGMENT IN LATEX.

In order to obtain a very pale, almost white crepe, for the manufacture of sole crepe, to meet a market demand, fractional coagulation of latex is practised on most estates which manufacture sole crepe.

The first fraction, which constitutes from 10 to 20 per cent or more of the total dry rubber content of the latex, is obtained by incomplete coagulation and contains a yellow colouring matter, which is precipitated with the first clot. The crepe from this first fraction is usually of a deep yellow or orange colour.

Also, when new tapping cuts are opened on a tree, or after resting, as in the periodic system of tapping, the latex and the rubber prepared from it, may be very yellow for several days.

This colour is not due to the oxidation of the non-caoutchouc constituents. This causes the normal darkening of raw rubber during drying which is in practice prevented by the addition of a small quantity of sodium bisulphite to the latex.

In order to ascertain whether it is possible to eliminate this colouring matter and thus avoid the losses and inconveniences due to fractional coagulation, an investigation of the yellow colouring matter has been carried out. The colouring matter was found to be carotin, which is present in a number of plant products and especially in carrot roots.

No satisfactory method of eliminating the colour was found, but a technique for the estimation of carotin in latex and raw rubber was worked out and the amount present was determined.

LECTURES.

Six lectures dealing with defects in raw rubber and factory methods and two lectures on soils (before the arrival of the Head of the Soils Division) were delivered before various District Planters' Associations and local branches of the Incorporated Society of Planters.

EXHIBITIONS.

Comprehensive exhibits were prepared for the Annual Agri-Horticultural Shows of the Malayan Agri-Horticultural Association held at Kuala Lumpur in 1927 and at Ipoh in 1928. These included samples showing the various defects of raw rubber, new methods of preparation including concentrated latex, aluminium utensils for estate factories, samples illustrating stages in the manufacture of rubber soled shoes and tyres (kindly lent by Messrs. Tan Kah Kee & Co.), Wilkinson Rubber Process articles, coloured crepe mats and a collection of photographs illustrating various aspects of the preparation of plantation rubber and of Fine Hard Para.

The writer and Mr. R. G. Fullerton acted as judges in the raw rubber section of the 1927 Show and Mr. Fullerton acted as a judge at the 1928 Show. The writer also acted as a judge at the District Agricultural Show in Malacca in 1927.

Rubber exhibits were also collected and photographs prepared and despatched to the Seventh International Rubber & Allied Tropical Products Exhibition held in Paris in 1927.

VISITS TO ESTATES.

Fifty three visits have been paid to estates by the writer and Mr. Fullerton in connection with defects in preparation and factory procedure.

PUBLICATIONS.

Planting Manual.—Planting Manual No. 1 "Guide to the Preparation of Plantation Rubber" was completed and published in 1928.

This guide contains concise instructions on factory procedure for the use of estates, and is based on the results of past investigations of the writer and other chemists, who have been working for some years on these problems.

Some of the recommendations contained in this Manual are based on recent investigations carried out by the writer which have not been published previously.

A similar guide has also been prepared for translation into Chinese and Malay for the use of small holders. The translation and publication of these is being carried out by the Department of Agriculture S.S. & F.M.S. which already issues a periodical for distribution among small holders.

Planting Queries.—The writer edited the second edition of "Planting Queries" for the Incorporated Society of Planters and also set a number of the questions and examined and marked the replies, in connection with a competition on estate practice, published in "The Planter."

GENERAL.

Rubber for Propaganda Purposes.—At the request of the Rubber Growers' Association, 30 tons of confiscated smoked sheet rubber, presented to the Propaganda Committee of the Association by the Governments of the Straits Settlements, Federated Malay States and Johore, were inspected and collected. Arrangements were made with various estates and firms to recondition and despatch the rubber to London.

Visit to Ceylon.—With the sanction of the Board and at the request of the Director, I spent a fortnight in Ceylon while proceeding on leave.

A week of this period was spent at the Headquarters of the Rubber Research Scheme, Culloden, in visiting a number of rubber estates and discussing collaboration of work and especially the question of a joint guide on the preparation of rubber with Mr. T. E. H. O'Brien, Chemist, Rubber Research Scheme, Ceylon.

A day was also spent at the Tea Research Laboratories, Nuwara Eliya, discussing research problems with the Director and his staff, and about four days at Kandy and Peradeniya to visit the laboratories and experiment station of the Department of Agriculture.

My thanks are due especially to Mr. O'Brien who accompanied me on all estate visits in the Kalutara district, to the managers of the estates visited for showing me details of factory and estate procedure, to Mr. J. Mitchell, Organising Secretary, Rubber Research Scheme, Ceylon, and the Director of Agriculture, Hon. Mr. F. A. Stockdale, C.B.E., and Mr. T. Petch, Director of the Tea Research Scheme, for their help. As a result of this visit, which enabled me to appreciate the different factory procedure on rubber estates in Ceylon and Malaya, and after consultation with Mr. O'Brien and the Director of Agriculture, Ceylon, it was decided that separate publications of a Guide for Malaya and Ceylon, containing recommendations for factory procedure, would be preferable, although the procedure in Malaya

as far as it concerned Ceylon would be adopted by Mr. O'Brien in a Guide prepared for Ceylon rubber estates.

The principal differences in Malayan and Ceylon practice are:—

- (1) The manufacture of blanket crepe in Ceylon and the manufacture of a smooth thin pale crepe in Malaya.
- (2) In the manufacture of sole crepe, the Ceylon product may be considered a mass production in the form essentially of blanket crepe, while the Malayan product is a highly finished thick smooth crepe built up carefully from closely knit smooth thin pale crepe, chiefly prepared by fractional coagulation.
- (3) The use of anti-coagulants in the field and factory in the preparation of smoked sheet does not appear to be generally necessary in Ceylon.
- (4) Only a few estates in Ceylon have adopted tank coagulation, which is almost universal on estates in Malaya.
- (5) The drying rooms for crepe in Ceylon factories are in most cases directly above the "wet" factory and hot-air drying is employed to a considerable extent. In Malaya, separate crepe drying rooms with air drying at ordinary temperature are used.

Differences between Malayan and Ceylon practice are due partly to variation in climatic conditions and partly to the fact that certain methods of preparation, e.g. the production of blanket crepe in Ceylon and the preparation of a smooth-finished thin pale crepe in Malaya, have merely developed without any logical basis. The marked difference between Ceylon and Malayan sole crepe is due essentially to these differences in preparation of the original crepe from which sole crepe is manufactured. Whether it is desirable to adopt uniformity in both countries in this connection is questionable. In any case the cost of any alteration of methods would be considerable.

The general use of an anti-coagulant (chiefly sodium sulphite) in Malaya is due to difference in climatic conditions. Latex in Malaya appears to ferment more rapidly, which produces greater natural coagulation in the field and development of bubbles in sheet rubber especially in tank coagulation.

The general use of large coagulating tanks in Malaya for the preparation of sheet rubber, which is seen only in a few estate factories in Ceylon, is due to the fact that estates in Malaya are generally larger and thus larger crops have to be dealt with. Pan coagulation is not satisfactory for large quantities of latex.

The use of separate crepe drying rooms in Malaya is essential on account of the high humidity of the atmosphere.

Visits in England.—At the request of Mr. P. J. Burgess, Chairman of both the London Advisory Committee of the Rubber

Research Institute of Malaya and of the London Committee of the Rubber Research Scheme, Ceylon, I attended meetings of both Committees.

I also paid two visits to the Imperial Institute to discuss problems of rubber testing, the question of variability in plasticity of raw rubber and collaboration with the Director and with the chemical staff in charge of this branch of work on behalf of the Rubber Research Scheme, Ceylon.

Two visits were paid to the Laboratories of the Research Association of British Rubber Manufacturers at Croydon, to see the plant and work being carried out and to discuss with the Director (Mr. B. D. Porritt) and his staff, problems on which collaboration might be possible.

Interesting and instructive visits were also paid to the Rubber Works of Messrs. Spencer, Moulton and Co., Bradford-on-Avon, and the Dunlop Rubber Works at Fort Dunlop, Erdington, Birmingham. Various problems were discussed with Dr. S. S. Pickles and Dr. D. F. Twiss the Chief Chemists respectively of these companies. My thanks are due to these gentlemen and to the Companies for permission to visit their works.

I was invited to lecture before the Institute of the Rubber Industry but unfortunately was unable to accept the invitation.

The question of preservation of latex with boron compounds was also discussed with Mr. A. J. Somer who is interested in the commercial application of these compounds and on whose behalf experiments have been carried out in the laboratories.

B. J. EATON,

Head of Chemical Division.

ANNUAL REPORT 1928.

Including Initial Period beginning June, 1927.

PATHOLOGICAL DIVISION.

INTRODUCTION.

In preparing the Annual Report of the Pathological Division it is the writer's intention, in addition to making a general statement of the progress of research on the major projects, to review briefly all matters which have come up for discussion in planters' meetings, lectures, visits and correspondence. This will involve a great many subjects which although of no great immediate practical importance in some instances are nevertheless of interest to the planting community, otherwise they would not have been made the subject of enquiry. Discussion of minor subjects of research in connection with as large a capitalistic crop as rubber should not be considered to be wholly academic.

The practical application of research is sometimes but dimly seen in the beginning. Frequently the question is asked 'what good is it unless you can apply it in a practical way'. The questioner overlooks two things, first that our several civilizations are very largely rated by the output of those things which give pleasure in one way or another regardless of their practical application, and secondly that practically all the progress the world has made has been due to making practical use of pure science investigations which in the beginning appeared to be wholly useless. When Mendel worked with crosses of sweet peas in his garden at Brunn the scientific world did not realise the tremendous importance of his work until a later day. His results were forgotten in fact, and rediscovered later. The significance of the early work on the application of horticultural practices to Hevea as regards improvement of yield was not fully appreciated and lacked support. The morphological differences in the pollen grains of the different species or races of Hevea is of more than botanical interest but these as well as other half-realised facts are not being investigated because of the urge for immediate practical results.

It is in justice to the plant pathologist to state that his labours have made plantation cropping possible. This is true from the standpoint of developing resistance in plants, of the interpretation of environmental factors in relation to disease, as well as of the more immediate work of prevention and cure. This of course is

well recognised in any scheme of agriculture where plants of like or related species are brought together in large number. If the plant pathologist has failed in the control of a disease resulting in great loss or abandonment of the crop, as has happened in the case of *Hevea* in some regions, such a result may not necessarily be attributed to lack of skill but lack of opportunity for early fundamental research or lack of financial support.

REVIEW.

ABNORMALITIES.

Hevea is influenced by different growing conditions and hereditary or inherent impulses may develop abnormalities of various kinds.

(a) Fasciation.—The flat band-like branches simulating ram or moose antlers are observed to be inherent in certain individual trees and are produced at successive intervals without the influence of outside agencies. A tree has been studied on which these fasciations had been pruned back to the parent stem. New shoots had developed at this point and these were fasciated. The abnormal branches which had not been pruned but which had died back to the more cylindrical part of the branch, as they always do, had regenerated shoots below the dead parts. These also were fasciated. These observations imply an inherent force and not external agents as the cause. Fasciation has been artificially produced in *Hevea* by mechanically manipulating the terminal bud and by forcing growth into a single lateral bud. Seedlings with the tops heavily infested with mites occasionally produced bandlike terminal or lateral structures due to the concentration of the mites on one side of the shoots.

(b) Warty Bark.—In rare instances peculiar types of hypertrophies of the bark of *Hevea* are found. In one type the bark bears flat-topped, pyramidal, 4- or 6-sided, laminated warts ranging in height from $\frac{1}{4}$ to $\frac{1}{2}$ inch. These warts which are composed almost entirely of cork may be uniformly developed over the entire surface of the older parts of the tree or may occur singly or in patches here and there. Trees having the above characteristics have been located and will be used for propagation purposes in a general study on disease resistance and inheritance.

(c) Tapping Panel Abnormalities.—The formation of small vertical parallel flutings or ridges on the tapping panel is causing considerable concern on some estates. The flutings are so pronounced in some cases that tapping would be difficult if the surface remained in its present condition. A comparison of tapping panels of different ages shows that with increasing age the flutings become less

prominent and may, with a sufficient renewal period, disappear altogether.

A study of the structure of the ridges shows that more rapid growth is taking place at those points, which implies an unequal distribution of food materials to the renewing bark. Deep or irregular depth of tapping or broad panels interfere with a proper distribution of food materials. The cell elements concerned in food transportation are to some extent severed in tapping and the elaborated food, to reach the renewing bark, must pass into the outer layers of wood above the panel or above the youngest part of the panel and thence into the renewing bark through the medullary rays. The fact that there are usually fewer and less conspicuous ridges on a panel of one third than on one of one half the circumference implies that the horizontal passage of food materials is less in the latter. Trees that are regularly tapped on the third eventually take on triangular shape in cross section. The zone of bark between the panels is less deeply tapped and more wood is laid down. It is recorded on one estate that the cylindrical condition of the trunk was restored by changing the system to one half the circumference. Cross sections of old tapping panels show that the amount of wood laid down in the region between the ridges becomes greater with each succeeding year, so that in time it equals that of the latter. Excessive penetration of disinfectants and protective substances where tapping is deep or irregular, great exposure to the sun, and protracted periods of dry weather are factors which influence the formation of ridges in that they affect the food supply to the renewing bark.

The large vertical ridges on trees are determined by the location of the major lateral roots but are in no wise connected with the small flutings of the tapping panel.

(d) Eccentric development of leaning trees.—Trees planted in peat soil, usually owing to subsidence of the ground level, become much inclined from the perpendicular. This induces an eccentric development on the upper or convex side of the stem which is a response to a demand for greater mechanical strength for support. The increased increment on the upper side of the stem frequently first takes the form of spiral ridges extending in the general direction of left to right upward. The direction taken coincides with the spiral grain which is a characteristic of a certain number of trees. The ridges may coalesce laterally, resulting in a pronounced thickening. The annual increment on the lower or concave side of the stem is very slow and the surface is smooth.

The irregularities of the stem are usually confined to a part above the tapping panel. Only when the ridges are formed lower down may tapping be made difficult on the upper side of the stem. Since this has been the actual result in a few instances the matter

has been discussed. Although trees growing in a normal upright manner do not ordinarily develop eccentrically there are certain cases in which is shown an inherent tendency to develop irregularities. Such trees should never be used as a source of budwood. The tendency in all leaning trees is to develop eccentrically. This is most marked on peat soils. Much can be done to keep the trees upright on such soil through a consideration of drainage and planting methods.

BLACK STRIPE.

Black Stripe has been found on a few of the low lying estates. The application of water-soluble fungicides after each tapping has been successful in a few cases. Where the disease is very prevalent the trees have been taken out of tapping. This should be for at least one month and a more permanent fungicide should be applied. A *Phytophthora* may be isolated from the lesions. Studies on the causal organism and experiments for control are being conducted by Mr. F. Beeley. For treatment see under "Mouldy Rot Treatment."

BROWN BAST.

A questionnaire has provided considerable information of interest on the incidence of Brown Bast in Malaya. Research is being conducted by Dr. E. Rhodes on the biochemistry of Brown Bast, the factors governing its appearance and control. High yielding trees heavily affected with Brown Bast have been pollarded for budwood in order to test the incidence of the disease in the resulting clones.

Brown Bast appears to be more common on estates than was anticipated and an effort is being made to give such instructions as will give the most efficient control.

The facts that large planting groups in Sumatra and several estates in Malaya have adopted for treating Brown Bast the isolation method of Keuchenius with satisfactory results, and that experiences in checking up the method in operation have been in the main satisfactory, appear to demonstrate its usefulness in practice.

The effectiveness of the method depends upon a regular and rigid inspection of the tapping cut and the accuracy with which the affected bark is isolated. The difficulty of diagnosing Brown Bast in early stages is shown by the fact that in all areas where the method is used the inspection reports always show large and small cases. It is known, however, that the percentage of large cases is reduced to small proportions where the method is practised. Early detection of Brown Bast is made difficult owing to the existence of a type of tree which develops a peculiar yellowish colour in the bark without any particular spot disturbance on the cut surface.

Such trees usually develop Brown Bast sooner or later but for a long time they may have a fairly high yield. Such trees are to be marked as suspicious and undesirable and to be removed in any future thinning operation. These trees usually develop Brown Bast rapidly and uniformly when they once start to go dry.

In the isolation method a piece of hoop iron is bent round so as to form a small loop and this is bound on the end of a stick. This tool is used to scrape out the exploration channel. An ordinary farrier's knife may be found useful for the purpose. The channel should not be cut with a gouge or any form of tapping knife. The Brown Bast tissue should be exposed by the scraping process for the reason that wounds are not so likely to be formed. The channel is extended to the right and left according to the direction the boundary of the Brown Bast tissue takes. The channel may be very irregular.

The depth to which the channel is cut depends upon the depth to which the brown or speckled condition extends in the bark.

The cut to the wood made in the bottom of the channel heals very rapidly and leaves little evidence of its presence after the bark is tapped off. In order to allow for irregularities of spread and difficult diagnoses it is a good practice to make the cut to the wood on the outer margin of the channel. The cut in the renewed bark above the tapping cut is usually made directly without an exploration channel.

The tree is not seriously damaged by the isolation cut if done properly. The examination channel is made sufficiently deep to determine the boundary of the affected tissues. Even if the wood is touched or exposed in spots the wound heals rapidly and by the time the tapping cut reaches the point and the bark is tapped off there is little evidence of wounding. Trees with thin bark may show more wounding than thick barked ones. A greater amount of wounding and of callus tissue occurs on the renewing bark if the examination channel is extended above the tapping cut. Here, however, the channel is rarely made but merely the cut to the wood. The method may result in wounding but this is of little importance in comparison with the effects on yield if Brown Bast is unchecked. Undoubtedly it is an effective method if used in connection with rigid inspection work. This is especially true in spotting and isolating small cases which would soon become big cases involving the entire tapping surface.

On the whole the method is physiologically sound. There are several small details which will come up for attention in practice. The work should be done by trained coolies who would give their entire time to the trouble. The amount of Brown Bast on estates would require the training and maintenance of such coolies.

The isolation method may be modified by beginning the exploration channel two inches below the tapping cut, the cut to the wood being made on the right and left to join the tapping cut with the channel. This is to prevent loss of latex and to allow the channel to heal before the cut reaches it.

Scraping or stripping of the isolated area may be used in conjunction with the isolation system in special cases. Stripping the bark alone is seldom to be recommended. Many trees so treated again develop Brown Bast. According to reports from estates recurrence is greater in stripped trees than in trees treated by any other method.

Inquiries throughout Malaya have shown that stripping has been on the whole rather disastrous, that Brown Bast has reappeared, that excessive wounding occurred with bark infections of various kinds and finally that the period of renewal necessary was too great.

A combination of deep scraping and isolation has been practised in both Malaya and Sumatra. This was done in Sumatra during the early investigations on the isolation method but the scraping of the isolated area was subsequently given up as not being necessary and the affected bark is now merely tapped off as the cut descends.

A combination of scraping and isolation is now being practised in Ceylon. Good results are claimed for the method and it is being recommended by the Research Scheme. The bark of the affected area is scraped down to the unaffected tissues or to where latex oozes and then isolated by making a cut to the wood all around the area. The scraped surface is then treated with 2 per cent or 3 per cent Izal or 5 per cent Brunolium. Tar 50 per cent or Jodelite 50 per cent have been used.

It should be remembered that unaffected latex vessels are frequently present in the Brown Bast tissue. Not infrequently a zone of latex bearing vessels is present between an outer and inner zone of Brown Bast tissue. If scraping is practised it should lay bare the tissues next to the cambium or until there is no longer any sign of Brown Bast tissue. Judicious deep scraping should not require a period of renewal of much over six years. In Ceylon the time between treatment and tapping has been found to be about four years in most cases.

Scraping alone was one of the first methods of control recommended. The belief that Brown Bast was caused by a parasite led to the application of tar and other substances. Finally stripping was tried. This in turn was followed by the isolation method.

CATCH CROPS, DISEASES.

The occurrence of some of the common root diseases of rubber on catch crops is of interest to planters but should

not be considered in a serious light. A comprehensive system of control should take into consideration the fact that any condition which increases the amount of organic material, dead or living, in the soil may be expected to increase the incidence of root disease. The fact that the roots of catch and cover crops are attacked is an indication that there is more inoculum in the soil for a particular site than is desirable. This is a condition in most cases over which the planter may previously have had little control. This being the case, more attention should now be given to keeping the base of the trees free from disease. As stated elsewhere the basic principle of root disease control is embodied in any scheme that will prevent infection of the basal parts of the tree. If this is done effectively much of the work on the inspection and elimination of lateral roots may be greatly reduced.

The following fungi have been recorded on catch crops, viz: *Fomes lignosus* on Coffee, Tea, Tapioca, Oil Palm, Coconut Palm, Gambier and Kapok. *Fomes lamaoensis* on Coffee, Tea and Kapok. *Ganoderma pseudoferreum* on Oil Palm.

CLEAN CLEARING.

Data are being assembled from all parts of the Peninsula on the factors governing the occurrence and conditions of spread of root disease in young and old rubber planted in cleaned and uncleared soil. It is expected that the investigation will furnish information for the more intelligent discussion of the problem of clearing in any degree at any time and of the practicability of establishing a system of rotation or pathological age classes. Rotation has for its object the progressive replanting of an area at an age when disease and poor bark renewal have made serious inroads on yield.

CORRESPONDENCE.

A large amount of correspondence has been handled in the Division. An effort is made to answer promptly all communications.

The Pathological Division seeks to serve the best interest of the planting community at all times. A hearty co-operation is solicited. All communications should be addressed to the Director.

COVER CROPS.

A nursery accommodating some ninety species of cover crops has been established at the Experiment Station. These plants, both leguminous and non-leguminous types, are being assembled from different tropical regions and represent all gradations in size from herbaceous to tree types. This nursery will serve for the study of cover crops, cover crop diseases and certain physiological reactions promoting disease in rubber.

Several blocks of rubber, planted seed at stake, stumps and basket plants, have been established with mixed cover crops in order to determine the relative period of survival of the various species on the same area. Other similar blocks, each planted with only one variety of cover crop, will demonstrate the tolerance limits in relation to shade, and incidentally the relation of cover crops to diseases of the rubber tree.

COVER CROP DISEASES.

What are probably the four principal fungous diseases of cover crops have been investigated in a preliminary study both under field conditions and under controlled experiments in pots. *Sclerotium Rolfsii* has either been found in nature or inoculated on *Vigna oligosperma* (*Dolichos Hosei*), *Calopogonium mucunoides*, *Centrosema pubescens*, *C. plumieri*, *Pueraria javanica*, *Mimosa invisa*, *Crotalaria anagyroides*, *C. usaramoensis*, *C. striata*, *Tephrosia candida* and *Leucoena glauca*. *Rhizoctonia solani* (*Corticum vagum*) attacks *Vigna*, *Calopogonium*, *Tephrosia*, *Mimosa* and *Crotalaria*. *Pythium* sp. has been found to cause a die-back of *Centrosema*, *Indigofera* and *Vigna*. These fungi either attack mature plants or cause a "damping off" or wilting of seedlings. The effect in the field is to cause the cover to die off in patches which may or may not regenerate, depending upon weather conditions. A paper has been published giving details on factors involved, methods of control and other important aspects of the problem.

COVER CROPS. RELATION TO DISEASE IN RUBBER.

Any condition that promotes a high moisture content around the base of the tree is favourable to root disease. Hence cover crops allowed to grow around the base of trees, especially young trees, are undesirable. The greater rapidity with which small jungle stumps decay when enveloped by a heavy growth of *Calopogonium* or *Centrosema* is a case in point. When covers are planted the base of the trees both large and small should be clean weeded. The fructifications and mycelial strands of *Fomes lignosus*, and the encrusting fruiting bodies and conidia bearing hyphae of certain harmful fungi have been found growing in early stages of infection abnormally high on trees surrounded by a dense growth of cover.

Under a heavy mat of cover plants the strands of *Fomes* ramify over the surface of the soil and follow the tap roots of the plants to their greatest depth, eventually causing their death. This condition has been studied in *Calopogonium* and *Vigna* and may be expected to occur with any cover.

These are extreme conditions and may be explained by the fact that the fungi were in great abundance in the soil before the covers were planted. Ordinarily *Vigna* does not form a very dense cover except in rich, moist, exposed situations.

That cover plants, whether herbaceous or shrubby, may be expected to afford an increase in nutrient substratum for mycelial development is by no means alarming. Plant cover plants by all means on certain soil types if possible. Nitrogen fixation, aeration and prevention of erosion are desiderata which outweigh all other considerations on most soils. On level porous soils where there is little or no erosion and where the rubber with increasing age is gradually developing a rich natural forest soil the planting of cover crops, it would seem, is quite unnecessary.

The conditions under which cover crops may be expected to promote root disease are to be found on areas where *Fomes* is abundant and then only when the cover develops a thick impenetrable mat. In such cases these areas or patches should be cleaned up as they appear. The trees should be inspected, the cover removed and the soil treated and cultivated.

CUTTINGS.

In connection with the work on *Sphaerostilbe* (which see) three cuttings of rubber out of twelve planted survived. They have been transplanted at the Experiment Station and so far are growing vigorously. The shoot of one is adventitious derived from callus tissue at the top. The other two have developed shoots from dormant buds.

DIE-BACK.

The dying back of the terminal branches of mature rubber has been the subject of many enquiries. The condition is not confined to any particular region but may be found in all rubber growing States in Malaya on certain soil types. In order to make a beginning in a study of cause and effect a special investigation has been made in Johore.

(a) *Locality.* Detailed observations were made on a few estates in the Johore River region and the opportunity was afforded to observe others in passing up and down the Johore River. During a previous trip from Johore Bahru to Mawai through Kota Tinggi the writer took the opportunity to look at some bad cases of die-back to examine growing conditions and to collect such fungi on the dead branches as seemed to have a bearing on the problem.

(b) *Fungi.* Since certain fungi have been mentioned in previous reports on die-back in S. Johore it may be of interest to record the most conspicuous species found on the dead terminal

branches of the trees examined during the two visits and to remark on their position as plant pathogens.

<i>Auricularia polytricha</i>	not	parasitic	
<i>Cryptosporella discoidea</i>	"	"	
<i>Daedalea repanda</i>	"	"	
<i>Daldinia concentrica</i>	"	"	
<i>Diatrype chlorosarca</i>	"	"	
<i>Diplodia theobromae</i>	"	"	usual form.
<i>Eutype caulivora</i>	"	"	
<i>Hexagonia pulchella</i>	"	"	
" <i>tenuis</i>	"	"	
<i>Hypoxyylon oodes</i>	"	"	
<i>Pleonectria heveana</i>	"	"	
<i>Polystictus flavus</i>	"	"	
" <i>hirsutus</i> (form)	"	"	
" <i>sanguineus</i>	"	"	
<i>Schizophyllum commune</i>	"	"	
<i>Stilbum cinnabarinum</i>	"	"	
<i>Trametes corrugata</i>	"	"	
" <i>ostreiformis</i>	"	"	

Certain other fungi were present on the dead and dying branches but experience with them and those named above leads to the conclusion that all may be placed in the category of dead wood fungi or as in the case of some of the species mentioned merely "wound fungi". They readily attack any woody material whose water content is reduced sufficiently to admit the amount of air necessary for the advance of the mycelia.

As the branches gradually lose their water content the fungi advance to that point where the air content is not sufficient for further development and are there held in check. The boundary between the advancing mycelium and the viable wood is generally marked by a conspicuous brown or black line (due to decomposition products) which may be regarded as a protective wound response against further decay. To demonstrate this point sections of branches were brought to the Laboratory and split longitudinally through the boundary zone between the living and fungus infected wood. A microscopical examination showed that the mycelium stopped more or less abruptly at the line of demarcation. After the wood had been allowed to lose moisture a second examination showed that the mycelium had advanced through the zone and was ramifying in the recently living tissues. This appears to be the same process as occurs in nature. As the trees lose vigour from insufficient nourishment the balance between the air and water content of the topmost branches is upset. Such fungi as *Diplodia* and other wound parasites are able to penetrate the wood and in turn are followed in such parts as are not yet occupied by their

mycelia by more typical saprophytes and the branches are soon completely decayed.

To summarise the foregoing, no fungus was found on the rubber trees showing a dying back of branches that is capable of attacking the upper crown branches under normal conditions of growth and none was observed to exhibit epidemic tendencies even under the existing conditions of poor nourishment and exposure of the host. A certain amount of root disease was observed in a few places but not in sufficient quantity as to cause the general picture of die-back so common on many of the sites of the region. There were no leaf diseases other than those usually associated with poorly nourished conditions.

The conditions which have brought some of the estates to a low state of resistance or rather to the period of readjustment between crown and root system may be considered under the following headings.

(c) Previous Cultivation. Land previously occupied for a number of years by Gambier, Pineapples, Pepper etc. may be expected to have lost a certain amount of its fertility, a condition that would be reflected in the quality of the vegetative growth of rubber. Whether this is true or not is a matter engaging the attention of the Soils Division of the Institute. In this connection it has long been the belief that the cultivation of tobacco, for example, impoverishes the soil to a great extent. Recent research tends to the opinion that it is not so much an actual loss of soil fertility as one of increased soil compactness, lessened aeration and gradual reduction of water holding capacity due to loss of the fine soil particles. Observations on rubber of the same age growing on previously cultivated land and on new land, both areas without soil conservation, indicate great similarity in quality of growth and an equal amount of die-back. This would imply that at least some of the factors of loss in growth are intimately related to physical conditions. The physical conditions that pertain in the region visited and are believed to be the underlying causes of stagnation in growth of rubber and the resultant dying back of the top branches are as follows:—

(d) Soil Denudation. Due to the fact that on many of the previously cultivated areas there has been no provision for retaining the fine soil either of the original forest or that of more recent origin, the water holding capacity and general fertility of the undulating land of the Johore River region has been greatly reduced. On these lands water runs off very freely. The problem of paramount importance is to get the water into the soil and to cause it to be retained. This may be done by the use of organic manures and silt pits.

(e) Silt-pits and cover crops. It would seem that the digging of silt-pits would be the first step in soil improvement. This is desirable for the reason that the loss of soil moisture by surface evaporation and run off, in the absence of any previous improvement works, has resulted in a hard baked surface on which it is difficult to establish cover crops. On one estate it was reported that on certain sites it was found impossible to establish cover crops. The lack of sufficient soil moisture is probably as great a factor in the failure to establish these plants as is the general loss of soil fertility. Silt-pitting would retain the moisture in the soil, collect the debris from the trees and would be a beginning toward establishing forest conditions viz., the retention of leaves and twigs in situ for soil improvement. This would add much valuable vegetable matter to the soil and increase its capacity to hold moisture. It is doubtful if rubber can be said to be growing under proper balanced conditions until that stage is reached. With the increase of fertility from natural processes the need for manures of any nature would become less and less.

The slight increase of evaporation of soil moisture through the activities of cover crops on an exposed soil would be entirely compensated it would seem by the greater capacity of the soil to hold moisture through the accumulation of organic materials. The difficulty of putting down cover crops on the hill lands of many of the Johore River estates will in some cases cause that particular means of soil improvement to be reserved until the soil has been better prepared by silt-pitting. Then the cover plants may be introduced along the borders of the pits with greater assurance that they will become established. If it is desired to attempt the improvement of soils, now in a low state of fertility, before silt-pitting special preparation would be necessary. The best method to employ would probably be the planting of seeds or cuttings in fertilized contour furrows. The selection of a cover crop that would also serve as a good green manure would be desirable. It is unfortunate however that most of the plants commonly used grow with difficulty on eroded soils. In such cases it would first be desirable to consider silt-pitting.

Reports of managers in the region that silt-pitting has greatly improved the condition of the rubber is sufficient to warrant the belief that it is the one means of retarding further deterioration of the estates from die back. The pathological factor of root trimming or root mutilation is generally counteracted by the large number of new roots developed from the regenerated root ends. These new roots usually strike downward and thereby tap a source of supply not recently drawn upon. The beneficial effects of silt-pitting would probably not be in evidence until after the second or third year. Excessive silt-pitting should be avoided as a slight temporary die-

back may result from such a practice. The soil between the silt-pits on some of the worst sites could be chankolled with beneficial results. This would cause the contact between the soil particles to be broken up, cause penetration of water and lessen evaporation at the surface through capillary action.

(f) Effect of Wind. It is to be noted that the estates in the region of the Johore River and those along the S. coast are exposed to winds of varying intensity which no doubt exercise considerable influence on tree growth both from the standpoint of evaporation of soil moisture and mechanical action on the top most branches.

(g) Conclusion. Die-back in the Johore River region is believed to be a direct result of the debility or exhaustion of food supply coupled with adverse physical conditions of the soil and exposure. The reaction of the roots to these conditions results in a diminution of the assimilatory organs of the higher branches causing them to die back gradually. Since the factors operative in the region are obviously those having to do with poor nutrition, soil moisture and exposure the problem becomes one of improving the growing conditions of the trees and is not one of dealing with the primary activities of fungi. The latter are believed to be purely secondary.

DISEASE RESISTANCE.

Under project I of the Programme of Work an effort is being made to learn what forms of Hevea show resistance to disease and to determine if resistance is due to hereditary (inherent) differences or to accidental differences in environment both present and past. For example, high yielding trees heavily affected by Brown Bast have been pollarded for vegetative propagation and budding will begin at an early date. To determine the influence of stock from trees apparently susceptible to disease on health of buddings, cuttings from trees which have had Brown Bast from an early age, trees having ordinarily abnormalities of various kinds, abnormal types, etc. will be budded. The difference in vigour between buddings on cuttings and on seedlings will also be shown.

EXPERIMENT STATION WORK.

Blocks averaging about 10 acres each have been established as follows:—

(a) To determine the incidence of root disease in uncleared soil under the different methods of planting and the relation of different types of cover crops to disease under these conditions and to determine the rate of decay of jungle material.

(b) To determine the incidence of root disease in clean cleared soil under different methods of planting and the relation of different types of cover crops to disease under these conditions.

(c) For the accumulation and intensification of pathogens in soil and trees for the purpose of obtaining experimental evidence on resistance and survival through the elimination of less resistant individuals.

(d) To determine the influence of continual exposure on the longevity of soil and wood destroying fungi, on the physical and chemical nature of the soil and on rate of decay of woody material in and on the soil under clean weeded and fallow conditions.

(e) To provide high yielding rubber for experimental work chiefly along lines of root disease control and disease resistance.

(f) To determine the role of disease in the sequence of survival of cover crops when planted originally in the same amount and under the same conditions and the influence of the factor of increasing shade on disease and survival.

(g) To determine the importance of the disease factor in uncleaned soil under forest environment and the rate of growth, general vigour, yield, cost of production, etc., of rubber under conditions simulating those of a small-holding and of a permanent high forest in which *Hevea* is the dominant species.

(h) For nursery and supply seedlings of different sorts for planting for nursery practice, study of nursery diseases and their control, for budding and general propagation in disease resistance work.

(i) To provide a nursery of the most important cover crops and green manure plants of tropical countries for the purpose of studying their diseases, species resistant to disease, their relation to disease in rubber, their general characteristics and cultural requirements under the conditions which prevail on estates.

(j) A block of one hundred acres has been divided into five plots of twenty acres each and planted under different conditions of cleaning with from forty eight to four hundred and thirty five trees per acre. This block is to provide an opportunity to study the relation of density, girth, taper, crown development (form, density branching), bark thickness, yield, bark renewal, root development, natural root grafting and conditions of the site before burning and after progressive selective thinning.

(k) To determine the effect of fire on the soil, soil fungi and growth of rubber and cover plants through a comparison of the conditions on an area not burned with neighbouring blocks where the soil is incinerated (soil nutrient and pH. values). Intensity of heat in the soil at different depths has been determined during burning by the Soils Division.

(l) To test the suppression of pathogenic fungi by non-pathogens.

(m) For testing fungicides and soil disinfectants against pathogenic fungi in the soil and to test the effect on pathogenic fungi of changes in soil pH. values by application of lime.

(n) Manurial work to strike the right balance between optimum growth and conditions unfavourable to root and leaf disease, e.g. soil acidity, etc.

Soil Conservation and Levelling. Owing to the fact that an ant-hill affords an attractive medium for root development and later through erosion of the hill the roots of rubber trees become exposed, it was found necessary to level several of the blocks which were excessively covered with the mounds.

To prevent soil wash by stopping the rain where it falls and to promote the building up of the top soil through the accumulation of natural debris in situ a system of closed bunding was used on Block 3. *Centrosema* was planted on the bunds as a binder.

EPIPHYTES AND PARASITES.

The study of epiphytic plants has received considerable attention. Tests for their control by the use of chemical sprays have been tried in a few cases. For lichens and liverworts, the most common of the smaller plants, a spray of Bordeaux mixture appears to be the most successful. The excessive growth of such plants is usually an indication that the trees are not growing under their best conditions with reference to drainage, poor soil or spacing and the problem should be attacked from that point of view. It is well to remark that all green plants found on rubber trees, with exception of the Mistletoes, are in no wise parasitic and are innoxious except in special cases. Mistletoe is common on rubber growing on dry sites in several parts of the Peninsula and may be easily eradicated by cutting off the branches on which the parasite grows.

FLOOD DAMAGE.

Kelantan.—In general five different sites may be recognised which were subject to flood influences and should be considered in any general plan for cleaning up and re-planting.

1. Bank or Shore Site, Higher level.—The deposits are as a rule deep, ranging in physical character from pure fine sand to coarser materials. Through the improvement work that has been done and through natural erosion a certain percentage of the trees were expected to survive. A certain percentage linger for an indefinite period and finally succumb owing to asphyxia of the roots and occasional infections.

The supply of oxygen to the roots on this site owing to the texture of the deposit is however, greater than on some others and the amount of the moisture less. The work that was done to improve the circulation of air in the deposit by trenching with outlets to the river was desirable. There is little more that could have been

done. Grass and weeds should be prevented from growing immediately around the base of the flooded trees. However there is little organic matter in a deposit of this kind and plants may not develop vigorously. As shown by the growth of liverworts and mosses on the upper branches and a certain amount of die-back a few of the trees were in low vigour before the flood. Such trees are likely to succumb. Fungus activity was not much in evidence. Wounds open to the wood on trunks were almost entirely due to mechanical abrasion, tarring having prevented infection in most cases and thus favoured formation of callus tissue. The wash of silt around the roots caused some wounds of a like nature which may be expected to heal where treated except where *Ustilina* has invaded the wood.

Aside from the danger of flooding the site may be considered as desirable. Trees should not be tapped for a time after floods and as the quantity of the deposit becomes less, as it will along the immediate bank, and its quality becomes improved through the formation of humus, the open spaces may be replanted.

2. Bank or Shore Site, Lower Level.—The deposits as a rule were not as deep as on No. 1 site but owing to the admixture of binding substances a more tenacious and impervious deposit was formed. On these low lying areas the trees not swept away were much diseased in the roots. Some of the infections were obviously pre-flood but in most cases the discoloration of the bark and wood of the roots indicated that the metabolic processes had been inhibited by a stagnant condition of the soil following the flood. There was nothing that could have been done to improve the trees. The site is of less value than No. 1. Since normal floods may be expected to cause unbalanced conditions for optimum growth it is questionable if rubber should be planted on the lower levels of the shore site. Fortunately the total area is small.

Broad trenches between rows leading to the river or to the ravines would allow the silt to be eroded away from the trees during rains.

3. Low Inland Site, Silted.—Some distance inland from the streams where the flow of water was slowed down by low lying basins or by heads of drainage areas there were silt deposits ranging in depth from 2 to 3 feet. The damage done to the present stand is irreparable and only a small percentage of the trees were expected to survive. The nature of the silt was such that the interchange of gases in the soil apparently proceeded with extreme slowness and induced asphyxia and decay in the roots. Fungi at the roots and at the forks were very noticeable. The discoloration of the roots would indicate that fungus activity has been largely induced by stagnation as a result of the deposits although some pre-flood infection occurred. The site should be systematically

cleaned up, drainage put down and with the aeration induced by the growth of weeds and grass the site could be again replanted or supplied. The total area of site 3 was apparently not very large and the loses in the future could be avoided by planting at higher levels.

4. Low Inland Site, Not Silted.—When there is an excess of stagnant water in a normally poorly drained soil preventing for any length of time the entrance of air to the roots, root rot is induced and the whole plant dies. The same cause leads to the formation of injurious humic acids which sets up fermentation in the bark of the roots, causing a foul odour and a dark blue colour of the wood and cortex. Fungi appear and the roots are soon decayed. This was the condition met with on a few occasions and was undoubtedly responsible for the dying out of trees on low areas where little or no silt was deposited. That both silted and unsilted areas showed dead and dying trees without any sign of disease other than that attributable to physiological disturbances demonstrates the injurious effects of foul river water on rubber growing in a normally over-wet compact soil. Without soil improvement work, viz. close set drains of appropriate depth and outlet and cultivation of the surface soil even to the extent of ploughing between the rows, trees growing in such a soil may not be expected to be free from die-back and certain injurious fungi common to such conditions.

5. Ravine Sites.—The rubber planted on the steep banks of the small ravines met with on some of the estates was in several places badly diseased. This rubber no doubt gives a fair yield but the trees are apt to be predisposed to disease due to the floods, consequently the site is unfavourable.

6. Miscellaneous.—Wounds to the wood should be disinfected and treated with coal tar.

When trees are attacked by borers it is an indication that they are so badly affected by flood and fungi that they cannot be saved.

All dead and dying trees should be destroyed, otherwise borers may develop in such numbers that trees but slightly injured will become infected.

The epiphytic plants (mosses, liverworts, ferns, etc.) on the upper branches of trees on flood areas are not parasitic but may be said to indicate slow growth. They are usually associated with stagnant wet soils. No attempt should be made to remove them except by way of improving growing conditions.

Sphaerostilbe follows soggy wet soils and may be counteracted by drainage and aeration.

Ustilina is common on flood areas. Trees with the fungus in the forks, on the sides of stems or at roots are in most flood areas so far advanced in disease they should be removed.

FOMES CLASSIFICATION.

Considerable confusion exists in the literature and as a consequence in the minds of planters on the proper botanical names for *Fomes* species attacking rubber. The genus *Fomes* of the family Polyporaceae (poroid fungi) is chiefly characterised by a hard woody persistent or perennial fruiting structure with or without stratification of the pore layers when seen in vertical section. The names that should be used are as follows:

Fomes pseudoferreus use instead *Ganoderma pseudoferreum*. The genus *Ganoderma* of the poroid fungi is based mainly on a well-defined spore character not present in other genera of the family.

Fomes lignosus. Owing to conflicting interpretations by various mycologists with reference to synonymy and place of first collection of the fungus we know as *Fomes lignosus* in Malaya, Ceylon and the Netherlands Indies, Petch has recently published his conclusions that none of the names which have been applied to it is the right one, and that it is really an unnamed species. The type or original material on which Klotzsch based the name is in the herbarium at Berlin. This material as well as a specimen from the type collection sent by Klotzsch to Fries, a part of which is in the writer's herbarium is identical with the common fungus of rubber in Malaya, Netherlands Indies and America known as *Fomes lignosus*. Spores are present in the Friesian specimen. These as well as other microscopical details including consistency of tissues are the same as found for the local and American collections, therefore the name *Fomes lignosus* should stand.

Hymenochaete noxia.—This name refers to a resupinate and often sterile form of *Fomes lamaoensis*. The use of the name should be discontinued.

FOMES.

Studies on the parasitism of *Fomes lignosus*, *Fomes lamaoensis* and *Ganoderma pseudoferreum* conducted under controlled and uncontrolled conditions show that *Fomes lignosus* is strongly parasitic and is capable of causing the death of six months old rubber without the supplementary action of any other organism.

Studies on Control. Tree inspection for root disease is being carried out on a nearby estate to determine the efficiency of control practices. Inoculations under aseptic conditions have been made to try to determine conditions of infection. The relation of soil acidity to the growth and spread of root fungi is showing important results in connection with the question of the use of lime. This work is being conducted by Mr. A. R. Sanderson.

The value of soil fungicides, especially copper sulphate, is giving results of considerable interest.

A more extended account of the problem of root disease control will be published later.

Fomes lamaoensis originally described from the Lamao River, Luzon, Philippines and the cause of the brown root rot of rubber has been found on almost all the estates visited and is shown to be a much more serious cause of decay than was formerly believed. It has been found to cause the death of Mangosteen, Rambutan and Soursop by direct attack at the root collar. It is chiefly responsible for a serious collar and tap-root decay of Gutta percha and Jelutong in the regions studied. The fungus has been found in four instances to cause a serious decay in the forks of rubber resulting in the breakage of the branches at that point. These infections were due to spores carried either by wind or insects. The spore producing capacity of the fungus, as determined by spore print tests, is great and may continue indefinitely, but the fructifications are usually rapidly destroyed by insects. The mycelium of the fungus has been found to extend through the soil a distance of sixteen inches from a major infection and to attack the mature parts of a neighbouring root. This means of spread which is favoured by the gelatinous nature of the hyphae and which causes the adherence of sand and gravel, explains the isolated spot infections.

FUNGICIDES.

A large number of fungicides are being tested. The object of this work is to determine the most efficient for the different purposes in order to standardise methods of disease control throughout Malaya. Publications on this work will appear in due course.

HERBARIUM AND MUSEUM.

From the beginning of the field work all pathological material of any value illustrative of causal organisms and conditions under which they operate has been saved for the purpose of instruction in the fundamentals of Hevea Pathology. These materials are being arranged in the Division's herbarium and museum to illustrate the practical aspects of the problems with which they are concerned.

The main idea behind the development of a pathological collection is that it shall be a place for profitable study of applied science. Too frequently institutions of research pile a mass of things together without any correlation or explanation of the facts concerned. The material is being arranged in cases and on the walls so that they draw spontaneous attention. It is hoped that the collection with

its abundance of definite and concrete material will become an agency of much educational value in the interests of the planting community.

HOLING.

To provide material for the study of natural placement and general configuration of root systems (see Root Form) in relation to root disease, stumps were planted in virgin soil at the Experiment Station without holing.

The stumps were merely thrust into holes made with a crowbar and the earth pressed around them. Not only have the stumps come away better than the controls planted in holes 2 x 2 x 2 feet, but are more vigorous in every way and stand out in the plot in a striking manner. A possible explanation is a better distribution of moisture in the undisturbed soil.

INSECTS.

Larvae of a small Lymantrid moth appeared in considerable numbers in certain districts during a dry part of the year. They did some damage to the freshly tapped surface in a few instances but control was in all cases established by hand-picking and spraying.

Orgyia turbata was reported as troublesome on young *Hevea* plants.

Acanthopsyche Snelleni.—"Basket worm". This pest was reported from several localities as attacking the panel in tapping.

A considerable number of enquiries have been received about insects on cover plants. One instance of attack on *Indigofera endecaphylla* was serious, the whole area being practically wiped out. The larvae of a small Geometrid moth was responsible for this.

A small Diptera (*Agromyzidae* sp.) the larvae of which make irregular burrows beneath the epidermis of *Hevea* leaves in nurseries has been repeatedly collected.

Several scale insects have been collected on young *Hevea* in nurseries. They have been identified by Dr. H. Morrison of the Bureau of Entomology at Washington as *Aspidiotus palmae* Morg. & Ckll. *Lespidosaphes tubulorum* Ferris, *Phenacaspis natalensis* (Ckll) and *Saissetis nigra* (Nietn.) These insects suck the juices from the green stem and cause distortion of leaves. Most insects of this nature may be controlled by lime sulphur sprays.

LEAF DISEASES GENERAL.

Considerable disease has been experienced in nurseries during the past year. The *Helminthosporium* leaf spot has been the

most common. Mites are usually associated with the fungus. During dry weather the mites which are favoured by such conditions are largely responsible for the damage. In most cases the seedlings recover from the attack without serious damage. If there is evidence that the terminal buds are being destroyed or are malformed, although not specially important at this age, the fungus and mites may be controlled by the use of a lime sulphur spray.

LEAF-FALL SECONDARY.

The death of the young leaves of rubber immediately or shortly after they unfold from the buds is the phenomenon commonly called secondary leaf-fall. The leaflets as a rule turn yellow, become brown at the tips, shrivel up and fall. Out of season fall of mature leaves may be due to a variety of causes but it is chiefly related to conditions of poor nourishment and protracted periods of dry weather.

Oidium has appeared on the young flush of leaves in several localities this year. The fungus is always associated with mites. In some cases the mite is the chief offender. Dr. Ewing of the Bureau of Entomology at Washington has determined the mite as *Tarsonemus latus* Bank. Apparently this is the first record of *Oidium* in Malaya. The fungus has done very little damage so far. It is hoped that this state of affairs will continue. Inoculation experiments on the method of infection and the resting stage are under way.

LIGHTNING INJURY.

The pernicious tendency of lightning to cause damage to plants has been well shown in rubber. Many cases have been investigated and talks with planters demonstrate the common occurrence of lightning injury to young rubber. The "die-back" of 4 to 12 months old trees wherein the tops wilt, the green bark turns black with the appearance later of 3 or 4 different caulicolous fungi, finally resulting in death, is apparently attributable to lightning. The affected trees occur in patches and when cut back to stump height regenerate rapidly with a discontinuance of the damage. The influence of lightning on the growth of trees, if the tree is not killed outright, usually takes the form of a modification of the developing wood cells of the season so that the continuity of the normal structure of the wood is broken and a 'lightning ring' is formed.

MOTHER TREES, PATHOLOGICAL CULLING.

The inheritability of abnormal characters in plants is well known. A certain number of *Hevea* clones have shown very

undesirable characters emanating, where their history is known, from the mother tree. These abnormalities may appear at a comparatively early age or may develop after tapping has begun. A few of the abnormalities of mother trees which are likely to be transmitted and become important in budded rubber as regards the tapping surface are as follows:—

(a) Tendency for latex to exude from ruptured vessels following the twisting and bending of branches during storms. This character is conspicuous on some estate trees and has appeared in certain clones.

(b) The abnormal plateau effect of the wood round dormant buds on the stems of smooth barked young trees. These elevated areas frequently coalesce to form pronounced spiral or irregular ridges and become very pronounced in trees planted in peat soil, especially if the trees become inclined to the perpendicular. The dormant buds of such trees may sometimes become stimulated and project above the surface. A clone has been studied showing this character to a marked degree.

(c) Trees with twisted or spiral wood. Some of the highest yielding trees occasionally exhibit spiral grain. This character, like the above, may become very pronounced with increasing age and under particular soil conditions.

(d) See also under Abnormalities.

MOULD ON RUBBER.

Some preliminary work on the classification of the moulds on smoked sheet and crepe has shown the desirability of studying the life histories of these organisms in greater detail with particular reference to the reaction of the different species to fungicides. The spores and mycelia of the different species exhibit varying powers of resistance to disinfectants. For this reason the use of a single disinfectant for all moulds found on rubber may not be as efficacious as might be expected.

The minute, borer holes in Chengal drying racks have been found to be a source of trouble in that the moulds, in particular a species of *Paecilomyces*, develop in these holes beyond reach of any disinfectant unless it is applied under pressure.

The moulds, which penetrate the sheet and may be isolated from the inner layers may not always be successfully treated by the external application of a fungicide.

MOULDY ROT.

The condition known as Mouldy Rot has received much attention. Studies show that mouldy rot is not always the result of the activities of a single organism but may be due to the combined action of several. For example, *Sphaeronema*, *Fusa-*

rium, *Diplodia*, *Aspergillus* and *Penicillium* have been found working in conjunction on a single tapping cut. Depending upon the weather conditions, any one of these organisms may be found working singly. All yield to the same treatment. The resistance of the resting spores of *Sphaeroneuma* and the best methods of destroying them are receiving attention.

MOULDY ROT. TREATMENT.

The following statement for the control of Mouldy Rot is appropriate at this time.

a. Treatment with trees in tapping.—Paint or spray with any good fungicide, a 2 to 3 per cent Izal or a 5% to 10% Agrisol after each tapping is good. Continue treatment until disease disappears. It is not advised to keep trees in tapping unless necessary. If it is economically necessary, owing to the large number of trees affected, to retain the trees in tapping a pest gang should be organised. The bark will not be seriously affected by the fungus if the treatment is given every 10 days.

b. Treatment with trees out of tapping.—Take trees out of tapping for 2 or 3 weeks or a month in bad cases. Spray or paint the tapping cut on alternate days, every 4th day or once weekly (depending upon the seriousness of the infection). Continue until disease disappears. Inspect trees every 10 days for recurrence until its disappearance is assured for the period.

c. Removal of scrap.—Remove and burn all bark scrap before applying fungicide. The scrap may contain all three of the reproductive bodies of the fungus. One of these reproductive bodies, the resting spore, which is frequently produced within the decayed tissues may be protected by the scrap if it is not removed.

d. Application of Fungicides.—The usual method is to apply with a brush, coconut husk or rag. A very efficient method is to use a small sprayer. A small hand sprayer could be used, or a knapsack sprayer if there is a large area to cover. A fine spray will penetrate into the interstices of the bark and will enable the operator both to cover more territory and to treat a greater area of the tapping panel. The quantity of liquid used is less and the disease is less liable to reappear owing to the more thorough disinfection of the bark.

e. Area of tapping panel to be treated.—The tapping cut and at least 12 inches of the bark above should receive the fungicide. The bark just below the cut should also be treated.

f. To distinguish treated trees.—A small quantity of lime may be mixed with the more colourless fungicides to indicate the trees and the parts treated and to act as a control of the coolie responsible for treatment. Methylene blue may be used for the same purpose.

g. Disinfection of utensils.—On an affected area out of tapping the cups, spouts and hangers should be removed and thoroughly disinfected in boiling water for an hour or more. Izal 5% to 10% or other fungicides may be added to the water and knives may be treated in the same manner. A very good method is to flame the knives or to keep them in Formalin overnight, or in any of the fungicides used. This treatment of the knives should always be given if the area is in tapping. Tappers from affected areas should not be transferred to other areas until knives and utensils are sterilized.

h. Reopening affected area.—Keep a close watch for any re-appearance of the disease and if present begin the necessary control measures at once. It should not be necessary to reopen 2 or 3 inches below the original cut, as is sometimes recommended, if the control work has been efficiently done. Tap less deeply on the original cut either during the period of infection or for a period afterwards. This is especially to be recommended during dry weather or during the wintering season.

i. Infected Kampongs.—Owing to the more favourable conditions for the development of the fungus on trees in smallholdings estates in close proximity to them should be carefully supervised. The appearance of the disease in smallholdings should be reported to the nearest Agricultural Field Officer or to the Chief Agricultural Field Officer, Department of Agriculture, at Kuala Lumpur. The disease is notifiable and treatment is enforced.

j. Fungi concerned.—“Mouldy Rot” is usually caused by the presence of two or more different fungi. A species of *Fusarium* is usually associated with *Sphaeronema fimbriata*, the true “Mouldy Rot” fungus, and it may alone cause damage, especially in thin tapped bark under exposed conditions. *Diplodia* is also a factor in the decay of bark during wet weather.

k. Black Stripe.—The same methods as for the prevention and control of “Mouldy Rot” may be employed for the control of “Black Stripe”.

l. Fungicides.—Various fungicides have been used. Izal and Agrisol are good. The former is strong and a little goes a long way. Brunolinum plantarium 1 part, coal tar 1 part, water 2 parts, containing 1 lb. soap in each 4 gallons of mixture has been used, or Brunolinum plantarium alone 5% in water, Cargilineum and Carbolineum at 5% or a mixture of coal tar and tallow rubbed in with the fingers to provide both an antiseptic and waterproof coating are substances used in different rubber growing regions. Cargilineum mixture B applied directly to the cut after removal of scrap and when the cut is dry is recommended in Ceylon. The cost is approximately 30 rupee cents per pound.

NURSERIES.

Three nurseries have been established and are now in use as useful and necessary adjuncts to the experimental work of the Division. One of these nurseries is at the Institute, another on a nearby estate and a large one at the Experiment Station. These nurseries are being used to test various fungicides, to afford supplies of seedlings for various plantings and will also be used for budding in disease resistance work.

In order that high yielding rubber may be available for experimental purposes budded stumps of clones Nos. 33, 49, 50, 80, 152, and 163 have been obtained direct from the A.V.R.O.S. and planted at the Experiment Station to form a multiplication nursery. Clones developed in Malaya will be added to this collection.

POD MATURITY.

The gradual exhaustion of the fleshy covering of the pod through the demands upon the food content by the developing seed induces, under certain conditions of moisture and exposure, the early appearance of a number of fungi.

Ordinarily these fungi do not appear until after the fleshy covering has completed its function viz. that of a protective envelope and source of food supply. It has been found, however, that pods on which there was vigorous fungous growth frequently produced immature or faulty seeds. This point was determined by selecting pods from the tree followed by germination tests. These preliminary tests are to be verified by more extensive work.

POLLARDING.

The question of the value of pollarding to offset "die-back", stagnant growth in poorly drained soils, the after effects of a too long submergence by water or silt in flooded areas, or irregular crown development is a question to receive attention by experimentation and cooperation with estates is being sought. Many observations have been made on estates where pollarding has been practised for one purpose or another. These observations show that rubber normally has an age when it produces shoots most vigorously, though this period varies with different types and under different soil conditions. This period of most vigorous regeneration lies in the early life of the tree while it is ordinarily under fifteen years of age. With increasing age this power to reproduce shoots becomes less and less until in the case of old trees cut to the ground the power may be entirely lost although the stumps may remain living indefinitely. The age limit of regeneration by shoots or sprouts, if the reaction in rubber is the same as in temperate zone trees, will be found to be later with

seedling trees than with trees originating from buddings or sprouts. The variability in the regeneration of severed branches by shoots in normally growing rubber of the same age class is a result of certain individuals being defective through disease, poor soil conditions or exposure, and consequently the power to produce vigorous shoots is lost and the stand presents a very ragged appearance. All the above conditions should be considered in interpreting the results obtained in any scheme for pollarding rubber. It has been observed that the tree regenerates better if the pollarding is done during or just before the wintering period.

Debilitated rubber resulting from impoverished soil cannot be improved by pollarding. The drying out of the dead wood attracts numerous wood-destroying fungi which gradually advance below the new shoots and cause them to succumb. If the main large branches are cut back the shock is so great and the amount of dead wood formed is so readily attacked by fungi that the trees are ruined and frequently die outright. A count of 75 trees so treated showed that 50 had succumbed to the treatment. If debilitated rubber is pollarded it is necessary at the same time to practise soil improvement physically and chemically. When this is done the trees will cast off all dead or moribund branches and pollarding is unnecessary.

The branches of flooded rubber may die back to one half or one third of their length or there may be an irregular and undesirable regeneration at different heights. If it is desirable to retain the trees the crown may be shaped up by pollarding. Ofttimes, as observations show, the regeneration is a temporary response and the trees gradually succumb to disease owing to the large amount of dead wood present. Pollarding of flood rubber can be practised only where the roots are unaffected. In this case the localisation of food material through pollarding will often cause the development of more vigorous shoots than those obtained in the absence of pollarding when the shoots are distributed along the branch.

An experiment to induce the formation of new roots on silted rubber at a higher level by wounding the bark just beneath the silt apparently failed.

Young mature trees broken at the forks by wind may be cut back to any height below the fork with good expectation of the development of vigorous shoots of which one may be selected to form a tree provided the yield futurity is worth consideration and the work is done properly. During the past year a count of trees on estates which have been cut back below the forks has been made. Out of a total of 25 trees 11 had either died at the top after the production of shoots or were gradually dying due to the advance of wood destroying fungi and fermentation organisms in the bark and cambium. A sloping cut at about 45° with a heavy water-

proofing of asphalt following a treatment of creosote will afford an excellent protection.

Talks with planters in different parts of Malaya elicit the information that there is a pronounced reduction of yield with little improvement afterwards in pollarded rubber. Moreover, the large number of wounds attract fungi and in addition the tree roots, if exposed are subjected to the drying effects of the sun to which they may not have been accustomed. It is the writer's opinion that general pollarding is not justified except in very special cases. In order to prevent wind damage to tall branching trees after thinning it is sometimes feasible to practise pollarding but the trees should be in a well nourished condition and the stubs should be thoroughly water-proofed.

PORIA.

No species of this genus of the poroid fungi has been found to be of importance as a cause of root disease on rubber in Malaya. Several species of pink or flesh coloured *Porias* have been found on rubber wood but none are referable to *Poria hypolateritia* or *P. hypobrunnea* species which are considered important on tea and rubber in Ceylon. The species found most closely related to the latter is *Poria porphyrophaea*. The microscopic details of the two species are very similar. *Poria hypolateritia* was originally described from India on *Myrica*. The type has hyphae 2-4 microns and spores 3.5×3 microns. The nearest approach to these characters is shown by a species found locally on *Hevea* with equally large pores and similar spores forming velvety strands over roots which may be referred to *Poria bracei*.

The fructifications of the species of this genus are always entirely resupinate, consisting merely of a layer of pores on the substratum, and are never reflexed. The name *Poria* has become associated with the decay caused by *Ganoderma pseudoferreum* but they should be held distinct.

RATS AND MICE.

Considerable damage by these animals has been reported during the year. Various methods and materials with special reference to poison bait have been tried without marked success. Calcium cyanide dust pumped into the burrows of the animals by means of a special pump has been found to be effective where the burrows are easily located. Since this is not always possible in a heavy cover such as *Calopogonium* or *Centrosema*, research has been concentrated on the development of "tangle foot" or bird lime. A poison is added to the mixture and it is then painted on the lower parts of the stem. The experiments so far show that the mixtures used are not injurious to the older parts of the stem.

ROOTS ADVENTITIOUS.

Roots which originate out of place or at later periods on uninjured cortex and on wound tissue have been observed in a number of instances. The tapping panels of native rubber when plastered with cowdung and clay occasionally produce roots especially near the ground. Basal wounds on estate trees excised in the treatment of cankers, when filled with similar substances, frequently produce roots. It is also a common phenomenon at the base of the tapping cut on trees which have been silted up by floods.

Thick, water-holding materials plastered on completed tapping panels to hasten renewal or to increase the thickness of the bark may be expected under moist conditions to cause adventitious root development at the base of the panel.

ROOT FORM.

Opportunity has been taken to study the form of roots of wind falls and of trees taken out in thinning in relation to infection by wood destroying fungi. It has been observed for example that the roots which owing to mechanical obstruction take a zigzag or irregular course were split and often decayed at the elbows or turns. This would imply that such roots during high winds are under a much greater strain than those taking a straight course. The pull during the swaying of the tree tends to straighten the root or to abrade it on obstructions in the soil with the result that at these points the root is more vulnerable to fungous attack. The condition is met with more generally in young rubber in loose, porous or gravelly soils. With increasing age and development of the root system the trees become so firmly anchored in the soil that movement is less liable to take place. Fallen trees which had been planted with unpruned roots stuffed into holes showed more abnormalities at the bends and turns of the roots than those which had been pruned previous to planting the latter having developed normal roots. Stumps and seedlings should be planted with lateral roots intact but the roots should be properly distributed in the hole or pruned to a reasonable shortness and not to the extent of simulating a carrot.

ROOT DISEASE IN JUNGLE.

In order to demonstrate that root disease patches on estates coincide with centres of infection in the forest, areas on the different plots at the Experiment Station showing the presence of root disease have been located. That this is actually the case has been noted in new plantings on estates where the jungle stumps are badly infected.

This work will furnish data of economic value in conducting control measures at the Experiment Station. Pathological maps indicating the principal seats of infection may be constructed and will prove of practical use later on.

ROOT DISEASE, RHIZOCTONIA.

Various species of the group are common in the soils of all tropical countries. *R. bataticola* not heretofore reported from Malaya has been isolated from rubber roots. It is said to be of great importance in Ceylon as a cause of decline or death of rubber leading up to infection by the common wood destroying fungi. The parasitism of the fungus under controlled conditions has been tested but so far the results have been negative.

ROOT DISEASE, XYLARIA.

During estate visits planters have pointed out black spike-like fructifications from one to two inches high growing on dead wood of wounds at base of trees. These fungi belong to *Xylaria*, a genus closely related to *Ustulina*, and they also produce black lines in the wood. They frequently follow up wounding from sun scorch, leaf fires, mechanical wounds, or may sometimes be associated with *Ustulina* in the same canker. As a rule these fungi are not of much importance. The treatment is the same as that for *Ustulina*. The species so far recorded on dead wood of living rubber are *Xylaria multiplex*, *X. plebeja* and *Xylaria deserticola*.

It is interesting to note that the fungi cultivated by certain of the mound building termites number among them species of *Xylaria*. In one case there was a definite connection between a nest from which *Xylaria plebeja* was isolated and an infection by that fungus on the roots of a tree.

SEED DISINFECTION.

To meet an enquiry on the use of tar on seeds to prevent them from being eaten by mice or destroyed by soil fungi parallel experiments were tried. Seeds coated with tar failed to germinate. The controls showed an 80% germination. Seeds treated with Semisan dust, a proprietary fungicide, promoted germination in the tests by 5%.

SNAILS AND PESTS.

The giant snail (*Achatina fulica*) has been found on rubber in Kedah but no damage has been reported. A common slug of the genus *Limax* has been found occasionally eating the tops of young seedlings. Damage from these molluscs has not been sufficient to attract attention. A small spiral snail,

(*Subulina octona*) which lives chiefly in the surface of the soil, attacks the roots of seedlings growing in damp soil rich in humus but it is apparently of little importance. It is interesting to note that this snail, according to Marshall, is one of the most widely distributed molluscs in the tropics and subtropics and probably originated in tropical America and has been carried to many parts of the world on plants. A small snail with only two convolutions to its shell, presumably a species of *Pupisoma*, is occasionally found causing corky proliferations on young stems. This snail has also been reported on *Hevea* in Sumatra.

SPHAEROSTILBE REPENS.

The bark on the lower ends of cuttings of *Hibiscus* and *Erythrina* was stripped off for a distance of three inches. The cuttings for a distance of 8 inches were next sterilised, and the exposed wood inoculated with *Sphaerostilbe* from pure culture. The cuttings were planted in sterile sand. After four months it was found that the fungus had grown vigorously over the surface of the dead wood and also over the callus region and the new roots, but had not invaded the living tissues. A certain number of the cuttings were prevented from producing buds and shoots so that they became weakened. Later, on examination, the callus and roots were found to be invaded by the fungus. The remainder of the cuttings grew vigorously and became permanently established although the fungus was present on the dead parts up to the time of the last examinations.

This experiment, although not very comprehensive, indicates that *Sphaerostilbe* is not parasitic in the ordinary sense and attacks only under certain external or environmental conditions which may bring the vigour of the host to a low state.

SPRAYING.

Because of the absence of any need for spraying rubber trees in Malaya—and it is hoped the need will never arise—the planting community in general is unacquainted with spraying operations and spraying machinery. In practically every instance where a fungus disease of rubber has assumed epidemic proportions the planter was totally unprepared to cope with it. Notable instances are the destruction of the Dutch plantations in Surinam by the S. American leaf disease, the Secondary leaf-fall in India, and *Oidium* in Java. In order to meet any emergency that may arise in Malaya this Division is being equipped with different types of hand and portable power sprayers of proved value. These will be used for general control work at the Experiment Station where demonstrations and instruction will also be given in the use of such equipment.

STEM DISEASE.

Two stem diseases of rubber, not heretofore recorded from Malaya, have been studied. Soft velvety coatings are sometimes found on stems of seedlings in nurseries planted in wet situations. This is the fructification of *Septobasidium bogoriense*. The fungus does not penetrate the tissues but may smother the bark causing constrictions. Two other species of the same genus which may be referred to *S. retiforme* and *S. fumigatum* have been found on the bark of mature trees but these were of no consequence.

The other disease of unknown cause is recognised by the formation of a series of concentric grooves or channels in the bark of mature trees. The bark of the diseased area flakes off but does not appear to affect the vital tissues. The affected trees appear to be covered with carvings and are of a consequence very conspicuous. This is known as the Ringrot disease in Java.

TAR AND TAR COMPOUNDS. PENETRATION STUDIES.

It is hoped to standardise the methods of wound protection by actual tests of a number of tars and tar mixtures. It is desirable to obtain a mixture that is cheap, readily available and efficacious. The first series of tests have been confined chiefly to depth of penetration. Mr. Sutcliffe, who has the work in hand, comments as follows:—"With regard to the tars and tar mixtures there is very little difference among most of them as far as penetration is concerned. In practically every case the penetration seems to be more or less proportional to the thickness of the corky bark. This was especially noticeable in those plants which had a corky bark of a very spongy texture. This is to be expected seeing that more tar will be absorbed by a loose textured bark than by a smooth one. On young trees the penetration is slightly greater over the brown corky bark than over the green parts. Penetration also appears to be greater near the lenticels and near minute cracks in the bark.

"It is possible that in estate practice the killing of the branch after treatment with tars may not be due entirely to the caustic effects of the tars but may also be due to closing of the lenticels by the preparation and the consequent lack of aeration."

Experiments are also being conducted with different types of asphalts for the treatment of wounds and for filling cavities. The results so far are very favourable. In view of the successful use of these materials in other regions it is expected that their use on rubber trees will prove to be most economic and efficient.

TAPPED CORTEX, RED COLOUR.

During the course of investigations on Brown Bast it has been found desirable to determine the cause and function of the red colour in renewing bark. The facts that this colour is most prominent in renewed bark on the most exposed side of the tree, that the colour is weak or absent in deeply scraped bark when coated with tar, that it does not appear in renewing bark on roots when deep in the soil show that it is evidently associated with a light relation and is possibly a product of the chlorophyll in the newly forming bark. The subject is of considerable interest in various directions and the experiments will be continued.

THINNING.

The pathological as well as the silvicultural aspects of thinning have often been discussed during visits and meetings with planters and it is desirable to review the fundamentals in this report. Thinning or improvement cuttings are made to improve the character and growth of rubber either in immature or in mature stands. Improvement in the form of the tree, accelerated growth and increased yield are specific objects. It is interesting to reflect that the principles of thinning would be considerably modified with the establishment of a system of rotation in rubber cultivation. For example, with a short rotation as would be practised on certain soil types it would not be so necessary to make improvement thinnings for the reason that the pathological conditions would not be greatly intensified. With a longer rotation, meaning of course an older age class of trees, one or more improvement thinnings would be advantageous. Pathological conditions would be more intensified and it would be highly desirable to remove all badly diseased, crowded and otherwise low-grade trees. As long as this class of material remains on the area it is a menace to the health and well being of the stand. Any tree that is not giving the maximum return for the space it occupies is an actual expense one way or another.

In general one of the first objects from a health standpoint is to thin out all undesirable trees. The next object is to aid growth and development of the best trees in the field so that they will have the advantage in the struggle for light and food. Not only should it be possible to bring a field of rubber to its maximum yield several years sooner than if it were not thinned, but the aggregate yield is greater than without thinning. Breaks in the canopy made by thinning soon close up. Thick planting followed by a comprehensive scheme of thinning determined in part by individual tree yields is to be very favourably considered. The disease factor should come in a different category.

USTULINA.

Demonstrations for the control of *Ustulina* have been made on several estates and certain conditions under which this fungus is especially troublesome have been explained. A rule that is usually put down for the control of the fungus on trees other than those of exceptionally high value is that if more than one quarter of the basal area is affected no control should be attempted. The tree should be taken out for the reason that if it is allowed to remain it is always a source of infection through the production of spores. The fungus may be controlled by carefully excising the wood in the canker to its greatest extent above and below the ground. The wound should then be treated. This may be done by heavily painting the exposed wood with asphaltic emulsion, a substance obtainable in the market ready for use or the wound may be treated with a mixture of 70 per cent crude creosote and asphaltic cement. The same treatment may be employed for branch and fork infections.

It has been found that a large percentage of *Ustulina* infections at the base of trees start under old accumulations of earth scrap. The bases of the trees should be kept clean.

VISITS.

The discussion of problems on the spot between the investigator and the planter has been a most profitable and interesting line of activity. Such work serves in two directions. The investigator obtains first hand information on specific problems of concern to estates and the management has the benefit of discussion not possible through the medium of correspondence. Sixty one estates have been visited. Estate visits should be arranged so as not to interfere with research work.

“WHITE ANTS.”

White ant attack on the roots of rubber in most cases depends upon the presence of decay, exposed dead wood, or such points of vantage as are not protected by the natural vigorous tissues of the tree. Trees of low vigour repeatedly subjected to encasement of the base above ground by white ants may be sufficiently weakened through the gradual encroachment upon the vital parts of the cortex as to cause fermentation and decay of the bark. Ordinarily encasement of the tree by white ants is not harmful. Wounds, natural or mechanical, or decay of the roots by wood destroying fungi enable white ants to enter the heart wood with the result that the tree is sooner or later broken or overthrown by the wind.

Any plan or method for freeing an area from root disease or for preventing decay in the base of the tree is fundamental for white ant control.

"WHITE ANTS", EARTH.

To check the influence on growth, incidence of root disease in trees planted on or near active ant mounds and the cause and nature of attack by the ants, trees are being marked for observation.

It is interesting to remark that trees growing directly in an active ant hill with the roots free from disease have not been attacked by the ants. The reverse has been found true where the same species of ant is concerned but with root decay present. (See "White Ants").

WINDFALL. FUNGI CONTRIBUTING FACTORS.

Root fungi as a primary or secondary cause play an important part in causing windfall as shown by studies on particular estates and by reports from planters. Poorly drained soils, moist sites, fire and other injuries, (prevalence of fungus infection), all contribute to increase the weakening action of fungi upon the roots and trunks of trees and thus increase the danger and damage from windfall.

All other factors being equal, a sound tree will withstand wind when a tree whose roots are rotted will be thrown or a tree whose trunk is rotted will be broken.

A large amount of damage to estates reckoned upon a financial basis, is annually sustained through windfall. A considerable portion of this loss can be traced to fungus action alone.

It is recommended not only as a measure toward increasing estate sanitation, but primarily as a preventive measure against windfall and wind breakage, that all trees marked to be reserved in selective thinnings should be free from root and trunk rots.

WIND DAMAGE, MISCELLANEOUS.

It is a common observation that latex runs down the branches of trees after periods of heavy rains and high winds. The latex oxidises and branches may be sometimes quite black. The latex appears to emerge directly from normal bark. It does in fact emerge from small ruptures which frequently do not heal. These in time increase in size and appear as black lenticular lesions up and down the trunk or branches. The flow of latex is caused by rupture of the latex tubes through bending and torsion of the branches and trunks by strong winds. The

effect has been produced artificially which shows that the phenomenon is in no wise caused by lightning as has been the usual interpretation in the text books on diseases of rubber. Some trees are inherently more prone to the injury than others. Some high yielding clones are subject to the injury to a high degree and should not be propagated for the reason that it is an indication that the buddings may develop abnormally. (See Mother Trees, Culling.)

J. R. WEIR,

Head of Pathological Division.

29th April, 1929.

ANNUAL REPORT 1928.

Including Initial Period beginning June, 1927.

SOILS DIVISION.

The period under review covers that from June, 1927, to December, 1928. The following summary presents the outstanding features of the progress and development during that time.

The Head of Division arrived to take up duty early in June, 1927. The Laboratory building was then in course of erection and the advisory work, which was already of some magnitude, was dealt with under makeshift conditions. The Head's office was ready for use in November, 1927, while the occupation of the main laboratory building took place in February, 1928. In the same month the first Assistant, Dr. C. Falconer Flint, arrived to take up the appointment of Soils Chemist. From that time onwards some of the earlier equipment began to arrive and it was possible to begin to organise the simpler analytical work and to train the necessary assistants. The delivery of full chemical equipment as well as the efficient functioning of gas, water and electricity supplies was not completed until the last months of the year. During the whole period the Bacteriologist was attached to the Division and submits a separate report. Mr. N. C. Jenkins, Field Officer, was also attached during the last fourteen months.

SECTION A. EXTERNAL ACTIVITIES.

SPECIAL TRIPS.

(1) A special tour of two weeks' duration was made in Sumatra during June-July, in company with the Head of the Botanical Division. The work of the A.V.R.O.S. station was inspected, and in particular the selection experiments of Dr. C. Heusser. A very full tour was made of the H.A.P.M. properties and experiments. The information there gained of their experience with plot experiments on rubber was most valuable, besides giving a very clear idea of the point reached in progress with such problems as tapping and manuring. Although a large part of these results has been published it was a great advantage to see at first hand.

(2) In March, 1928, two weeks were spent in Kelantan with

the Head of the Pathological Division, investigating the effects of the 1926 flood. During these floods whole fields of rubber were submerged for days. The direct damage due to this submergence and to incidentals such as impact of floating debris was small compared with the after effects of silt deposits. This was clearly shown by the comparisons between sites along the main river where the flood water carried a great deal of sediment, and those along tributaries (e.g. the Nal) where the water remained comparatively clear. So great was the disturbance that after 15 months the river still carried an abnormal amount of suspended matter. The flood waters deposited their suspended material in a most interesting manner depending upon the rate of flow of the water at different spots. The method of elutriation has often been used in laboratories for mechanical analysis of soils,—that is the division of the component particles into groups according to size. This process was effected on a gigantic scale during the flood. The deposits tended very much to consist of particles of one or two size groups only, according to the conditions ruling at the particular locality. This is clearly shown in the accompanying table. I am indebted to Mr. Sutcliffe of the Pathology Division for the samples, which he collected during a tour a few months after the event.

MECHANICAL ANALYSES OF KELANTAN FLOOD SILTS.
DECEMBER, 1926.

R.R.I. Sample	Number.	119 B.	129.	119 A.	125.	127.
Sand	...	87.0	57.4	6.6	.5	3.0
Fine sand	...	9.1	29.8	42.7	2.9	2.1
Silt	..	.7	3.5	20.3	29.0	13.8
Fine silt	...	2.5	4.8	20.0	40.6	24.4
Clay	...	1.0	4.3	9.1	25.8	56.1

The first sample, No. 119B, is typical of the sand deposit made along the top of the normal river banks. Here the force of the current received its first check and the coarser particles were deposited. Although this deposit was often six feet or more in depth, so that the trees had to be dug out, it was confined to narrow strips. Owing to its high porosity and quick drainage it did comparatively little harm.

Deposits behind the river banks, containing mostly silt or clay fractions, were much more widespread. They varied in depth from a few inches to a couple of feet, and in practically all cases produced the same disastrous effects on the trees. Owing to their texture they formed a most tenacious air-tight seal over the surface of a soil already water-logged. In their first slimy state it

was impossible to carry out any effective drainage or removal work. Later they dried with a hard outer crust but remained wet and semi-fluid below for a long period. Conditions in the normal soil buried in this way became sour and conducive to disease organisms (change from aerobic to anaerobic conditions). The attack from these was very much favoured by the weakened condition of the trees, which naturally suffered a great shock from the sudden change in their root environment.

The very finest particles (the so-called colloids both organic and inorganic) would, of course, be entirely carried away by the flood waters. It may be suggested that the lack of this colloidal fraction accounts to a large extent for the very obdurate behaviour of the deposits. The general property of a fertile soil is that, however hard a clod it may form when dry, it will crumble under the action of rain. These deposits dried very hard and with very little sign of shrinking, and when again wetted there was no ameliorating action. They proved fairly fertile, however, to the large number of small seed which they contained, and were in general quickly covered by a weed growth. It is to be expected that these adverse physical conditions of the deposit will gradually disappear, so that, however much damage has been done to the stand of trees, the fertility of these sites may ultimately be improved rather than diminished. But it should be said that sites which are liable, even at long intervals, to such inundation, cannot be regarded as really suitable for a permanent planting such as rubber.

ADVISORY WORK.

The Head of the Division has dealt with upwards of 625 letter enquiries. Of these more than half concerned the subject of manuring.

76 estates were visited in the course of advisory work, many of them more than once. Of the visits 59 were made by the Head of the Division.

The correspondence makes it plain that there is a rapidly growing interest in the possibilities of improving old or badly developed rubber by manuring. The use of manures for nursery plants and similar purposes is too well understood to need special mention, except to remark that the assistance to be gained in this way is often great and too frequently overlooked. The problem for old rubber offers many difficulties and uncertainties of its own, which from the nature of things must take a great deal of time to settle. On the usual basis of reckoning, the cost of manuring bears a high ratio to the value of the crop harvested, while the stimulus to crop production is much more indirect than in most

cases. On the other hand the period over which benefit may be spread is likely to be longer. It may be said that at present the results do not warrant the expectation that ordinary manuring methods will economically increase the yields of moderately good areas. The most promising cases are those where marked starvation exists without particularly adverse conditions as regards drainage, moisture supply, and similar physical questions. These cases fall into two groups, namely, stunted growth due to a site originally poor (exhaustion by previous cultivation, etc.) and retrogressive yields and die-back due to soil deterioration (loss of reserves by erosion and exposure, or failure of reserves due to a thin soil layer.) In such cases manuring may be relied upon to bring back a healthy foliage or to stimulate growth. Improvement in yield is often delayed, but generally follows.

The more specialised problem of bark-renewal proves the commonest of limiting factors. Bad renewal is found even where otherwise there are no signs of poor nutrition. This is therefore being treated as a subject for special investigation and experiment.

Next in importance to manuring have been the enquiries relating to the cultivation of cover crops. Here again the advantages of their application to young areas for soil conservation are very obvious and straightforward, but undue optimism is shown in many quarters regarding the application to old rubber. One point should be mentioned in passing. It is often remarked that young rubber under clean weeding grows more rapidly than under a cover. This is a natural consequence of the rapid oxidation of humus under conditions of soil exposure, which gives a rapid renewal of food supply. But the conservation of soil capital afforded by a cover must be regarded as very cheaply purchased at the expense of a slightly slower maturing of the main crop. There can be no doubt that most sites under mature rubber in Malaya do not afford congenial conditions for the growth of leguminous covers. Often it is a case of moisture supply, often a case of crowding out by the rubber itself both as regards light and food supply. It must be borne in mind that the natural conditions under vigorous rubber should be those of a forest—the living cover sparse from shading and the soil carpet a dead detritus from the trees. To these conditions the processes usually understood by cultivation and green-manuring are somewhat foreign.

With the above limitations in mind there are many undoubted advantages to be gained from leguminous covers, if the difficulties can be overcome without undue expense. Many experiments with manures are being tried, with indifferent success unless very heavy dressings are given. It is noticed that in most cases root nodulation is conspicuously absent, and the attention of the Bacteriologist was early drawn to the question as to whether the practice of seed-

inoculation would not prove of very great advantage. The practice has in other cases solved the difficulty of introducing legumes to districts new to them, as, for example, the spread of lucerne in England.

Since the great question in nearly all tropical soils is the keeping up of adequate humus, green-manuring comes into its natural place in questions of soil restoration in replanting. This question is likely to receive small attention until there is much greater difficulty in finding virgin land for planting. But a beginning is being made to explore on a small scale the possibilities of reconditioning and replanting old areas where, from tapping injuries or other reasons, no promising alternative action offers.

One special class of replanting problem needs mention, namely peat areas. Here it is not a question of loss of productivity of the soil, but of damage to the stand of trees following the inevitable erosion of the peat by oxidation. Feeding roots are terribly exposed, while the mechanical hold is so poor that an upright position (so necessary for tapping) is not maintained. Such sites may offer good prospects for replanting. Certain points must, however, be kept clearly in mind. Great injury may be done to peaty soils by undue exposure to the sun. Not only does a sterilising action follow which arrests the natural decay, but, what is more vital still, an irreversible drying out takes place. Once dry, the material does not again take water into its finer pores owing to the presence of small amounts of waxy substances, and it becomes a most unsuitable medium for plant growth. It is therefore specially necessary to keep peat under the shade of a cover during any replanting operations. Another feature in this case is depth of drainage. Old peat areas are often very deeply drained. This is not suitable for the restricted root range of young plants growing in a very porous medium, and the water table should be temporarily raised to meet this need.

Several special cases arose in which advice was sought to clear up a doubt regarding drainage or some similar question, having reference to the particular conditions on the estate concerned.

LECTURES AND PUBLICATIONS.

Lectures were given by the Head of Division at two of the Annual Conferences of the Incorporated Society of Planters. The first, at Penang, in August, 1927, was entitled "Physical Aspects of Soil Conservation" and was published as a special reprint by the Incorporated Society of Planters. The second was at Port Dickson in August, 1928, under the title of "Some Considerations on Silt-Pitting." This was published as a contribution to the first number of the R.R.I. Quarterly Journal.

Nine other lectures were given (making 11 in all during the period) to various District Planters' Associations. The subjects covered the points of general interest concerning soil conservation, cover crops and manuring.

The Head of Division published jointly with Dr. B. A. Keen, Assistant Director of Rothamsted Experimental Station, the following papers:—

- (1) "A New Dynamometer, suitable for all types of horse and power drawn implements," read before the First International Congress of Soil Science in Washington, June, 1927.
- (2) "A New Form of Traction Dynamometer." *Journal of Agricultural Science.* October, 1928.

An article on Manuring was also written at the Director's request for the Secretaries of the Planters' Association of Malaya for incorporation in the P.A.M. Year Book.

The preliminary report in a letter to "Nature" of the results concerning a special research subject, is mentioned elsewhere.

EXPERIMENTAL STATION.

A number of exploratory visits were early made to the area in the Sungei Buloh Forest Reserve allotted for opening the Experimental Station. Later, the Field Officer collected soil samples at regular intervals along the median line of the area first opened up. This was preliminary to the collection and storage for future reference of a representative series over the whole area.

The area so far opened is almost entirely flat, and has a very uniform sandy soil of variable but very considerable depth. This overlies a white clay subsoil. Only where swampy conditions have led to an accumulation of organic material is there much deviation from uniformity. The mechanical analyses of four samples representative of the area now opened are shown below:—

No.	Loss on Ignition.	Sand.	Fine Sand.	Silt.	Fine Silt.	Clay.
I B.	4.6	75.0	13.6	1.2	2.8	5.8
III B.	7.1	70.1	17.2	1.7	4.9	4.8
V B.	6.5	76.0	13.4	1.2	5.0	3.6
VII B.	5.1	79.5	10.6	1.0	3.8	3.1

Thus the sand and fine sand fractions amount to 90 per cent. The chemical analysis of VII B. gave the following figures:—

Nitrogen	...	1147	parts per million	} C/N ratio 23
Carbon	...	26340	"	
Phosphate (PO ₄)	...	746	"	
Potash (K)	...	40	"	

As would be expected from such a sandy soil the plant nutrients are present only in very small proportions. This is offset by the considerable depth of the soil which is available for feeding the trees. It is our experience that smaller amounts of phosphate have proved adequate on soils of similar depth. The organic material present is in the early stages of decomposition as is usual in such a soil under tropical conditions. The products of decomposition do not accumulate but pass rapidly away. This reserve of organic material cannot be expected to last for any length of time in such a well aerated soil. The particular soil sample under discussion was from the neighbourhood of the manuring experiment. Since the site obviously affords an excellent physical medium for the trees and is not well provided with plant food, it should afford a good opportunity for demonstrating the effects of artificial fertilisers. On the other hand the small amount of clay does not promise much retentive power and applications may not be economically utilised.

Other samples of soil from the Experiment Station have shown up to 20 per cent. of clay and organic material in a better state of humification. It is certain that areas not yet explored in detail will afford better planting land than that discussed above.

As proposed in the Programme of Work, the first plots to be laid down at the Experiment Station were a standard series on manuring. A 40 acre block was assigned to the Division for this purpose and was the first of any to be planted in October, 1928. The plan chosen was that of a latin square of 36 plots, giving six different treatments six times repeated. The arrangement is such that each treatment occurs only once in each row of plots whether taken N to S or E to W. The planting is uniformly 22 feet x 22 feet and the boundaries of plots are marked by a row of trees excluded from the experiment. Thus each plot is rather less than 1 acre and consists of 9 x 9 trees in square planting. The treatments chosen are as follows:—

- (1) Control.
- (2) Complete organic (dung was the first dressing given).
- (3) Complete inorganic (i.e., nitrogen, phosphorus and potassium).
- (4) Nitrogen alone.
- (5) Nitrogen and phosphorus.
- (6) Phosphorus and potassium.

The first treatment was given to the earth for filling just prior to planting. The planting material was ordinary first class stumps, as it was desired that the stand of trees shall be truly representative of the existing stands of rubber. As a conservation measure the area was put under Vigna which will be eradicated and slowly changed over to clean weeding as the trees develop.

CO-OPERATION.

A short piece of co-operative field research work was undertaken with the Forestry Department during March, April and May, 1928. Mr. E. J. Strugnell was conducting an intensive survey of chosen small areas in the Sungei Buloh Forest Reserve. Soil samples were taken on these, while certain recording meteorological instruments belonging to the Division were used for the investigation of temperature and humidity. The following is a summary of the results obtained:—

Soil Samples.—10 to 12 per cent clay and 80 per cent sand and fine sand combined. Very uniform down to the two feet explored.

Conditions under Forest.—The climatic conditions near the ground under jungle are very uniform. The humidity of the air remains at saturation point and the soil remains permanently wet. The mean temperature of both the air and the soil is 75° to 76° F. The daily variation in soil temperature even at the surface is only 1° , which gives practically the conditions of an incubator. The daily variation in air temperature is between 10° and 12° a few feet from the ground and increases slightly with height among the trees, viz., 2° for the first 25 feet and 1° for the second 25 feet. The humidity of the air at these higher levels also falls during the day, in a way depending closely on the amount of bright sunshine.

The Division has to thank many Estates for co-operating in the conduct of experiments and in placing their data at the disposal of the Institute. It is impossible to do without tests carried out in different parts of the country to secure variation in soil and climatic conditions. The Division has been in touch with some 36 manuring experiments by means of correspondence and visiting. Of these a large number provide us with periodical returns. These show cases of distinct gain as well as many of an inconclusive character, but the experiments are on the whole too young for full analysis to be usefully attempted. Excluding the special cases, the two features which appear to be very general are the very quick and marked effect which manuring has on foliage and the slow manner in which that improvement works itself out as yield returns.

SECTION B. INTERNAL WORK.

ORGANISATION.

Dr. Flint has very ably forwarded the organisation of the internal work of the Division. The setting up of equipment and

training of assistants for routine work has taken up much time. At present three helpers are afforded, who, in order of age and training, are undertaking the chemical analysis (including pH determinations), mechanical analysis, and meteorological records respectively.

The present state of chemical science and of soil research in particular allowed us to take advantage of very modern improvements in arranging equipment and organising routine work. In regard to apparatus in particular we have equipped ourselves for the use of micro-methods of analysis. Besides the gain in saving of time and in ease of manipulation, the saving in chemical material is of great advantage to a laboratory so far from a source of supply.

Much time has been spent in developing suitable methods of analysis. Dr. Flint's Divisional Report shows the successful manner in which he has adapted the latest methods, including his own previous researches, to the working out of details of methods for routine analysis. The routine workers are now in possession of detailed methods for the estimations of pH, nitrate, carbon, phosphorus and potassium, all selected as regards suitability for local soils and their extracts.

During the period 120 soil samples were subjected to mechanical analysis. Of these certain ones received chemical investigation, but it is clear from the date of arrival of material for this work that it could not be carried very far. The demand for reports on soil samples has been quite continuous and insistent, and we have to apologise for the frequent delays which have been unavoidable in the circumstances. From our experience in correspondence the following few remarks on the subject will not be out of place.

A full soil analysis is a task which requires much time and skill for its proper execution. Its interpretation is also often very obscure without the addition of a good deal of other local information. One has only to think of the tremendous variations in the amount of soil available for the trees (since rubber has been planted in soils from a few inches to many feet in depth), and of the many variations as regards previous treatment of the site, to realise the limitations of analysis figures when they stand alone. It is therefore strongly urged that soil samples be carefully selected with a clear realisation of the problem on which advice is sought, that unnecessary multiplication as to number be avoided, and particularly that a full description as to local conditions should accompany them. It must not be forgotten that the trees themselves generally offer to inspection more certain evidences of site deficiency than conventional methods of chemical analysis afford.

Field Officer.—Mr. N. C. Jenkins was engaged on very varied work connected both with the Division and with the general interests of the Institute.

Among the latter items was the production of a 'spot map' showing the Institute's activities up to December, 1927. Time was also given to the workshop, both as regards indents for equipment and the preparation of plans for the layout. Two exhibitions also claimed attention for transporting, arranging and demonstrating the exhibits sent by the Institute.

The Field Officer visited 25 estates while with the Division and reported upon 17 of them. Maps were also prepared summarising (1) the official rainfall data for the Peninsula, (2) a series of soil analysis data kindly loaned to the Institute from the records of the Agricultural Department. It was very plain from the latter examination how inadequate is a chemical test of a rubber soil unless re-inforced by a knowledge of the physical factors present.

Much time was given to the preliminaries for pot-culture work. These included the searching of literature for relevant details (mainly fruit-tree culture) and the discovery of a suitable local supply of sand, etc. Possible sites for the erection of a pot-culture house were also surveyed.

The Field Officer gave assistance in all activities at Sungei Buloh, particularly with the taking of the special meteorological records there.

METEOROLOGICAL.

The main characteristic of local weather is its uniformity. There was therefore little point in providing for a complex series of routine records, since a fully equipped Government Meteorological Station stands not far from the laboratories, and attention was focussed upon the provision of records of a special nature bearing directly on the research side of the work. The special aims and equipment were previously outlined in the Programme of Work for the Division. Of that Programme all the meteorological work has been successfully started, with the exception of the drainage tanks. We have to thank the Government Meteorologist for the loan of a Stevenson screen and various items of standard equipment. The special equipment, together with a summary of results so far obtained, is discussed below.

RADIATION.

A Callendar Recorder was installed in February, 1928, for the registration of solar radiation. This instrument gives a daily chart showing a continuous record of the radiation intensity at

a fully exposed horizontal surface. From the chart daily entries are made of (1) the maximum intensity reached (with time of day) and (2) the total radiation as given by a summation of the chart by means of a rolling-type planimeter.

As a basis of comparison we have the following values. The solar constant, or radiation intensity for normal incidence without appreciable atmospheric absorption, is 1.93 gram-calories per sq. cm. per min. This would give as a maximum value for a day's radiation at a horizontal surface 888 calories per sq. cm. (i.e., a day from 6 a.m. to 6 p.m. with the sun passing directly overhead and no radiation being intercepted before reaching the ground).

A preliminary examination of the Institute records for the 11 months gives the following figures. Total radiation during a full year 177,800 Kilowatts per sq. decametre. Translated into rough units more easily visualised it might be said that this yearly amount of energy, if derived by the combustion of coal, would require over 850 tons of that fuel per acre. Similar annual totals recorded for other places are:—

London (South Kensington)	78,570	Kilowatts per sq. decam.
New York	... 97,860	,, ,, ,,
Washington	... 145,400	,, ,, ,,
Johannesburg	... 175,700	,, ,, ,,
Stockholm	... 79,270	,, ,, ,,

The maximum intensity reached during the day at Kuala Lumpur is most usually about 81 per cent of the solar constant, while a value of 87 per cent is rarely exceeded.

The maximum day's value of radiation occurred on Sept. 2nd with 626 calories per sq. cm. (or about 70 per cent of the maximum possible).

The lowest day's value was on Dec. 22nd with 76 calories per sq. cm. Mean daily total 433 calories per sq. cm.

It is interesting to note that the maximum for a day at Kuala Lumpur corresponds almost exactly to the maximum for a day recorded in England (Rothamsted). The greater length of the day and the lower humidity during clear weather in early July at home compared with conditions in Malaya, apparently compensate for the difference in the sun's declination.

The uniformity of the radiation throughout the year may be expressed by saying that the standard deviation of weekly totals is only 9.5 per cent of the mean. In fact, the only perceptible seasonal variation is that due to the two regular periods of greater rainfall.

RAINFALL.

For the purpose of soil erosion studies the most important factor requiring measurement is that of rainfall intensity. The

rate of precipitation is plainly of more consequence as regards "soil wash" than is the total precipitation. Since the small recording rain gauge of standard pattern is not well adapted for accurate measurements of this kind upon rainfall of tropical intensity, a large gauge was specially erected. Advantage was taken of a recording tank designed and made by Messrs. Negretti & Zambra to the specification of the Rothamsted Experimental Station, and a duplicate was secured. This was erected in its own house and provided with a funnel (approximately 1 yard square) of an area suitably reduced from the original design so that the tank-capacity of about 22 gallons represents a total rainfall of 5 inches instead of the 1 inch originally intended. The chart obtained from the gauge is sufficiently open for a first differential (or rate) to be taken from the curve with requisite accuracy. The following table summarises the records from March onwards:—

RAINFALL AT R.R.I., KUALA LUMPUR.

Month.	Number of rain-days.	Total for Month.
March	... 7 ...	6.81 inches.
April	... 15 ...	11.62 ,,
May	... 13 ...	3.30 ,,
June	... 7 ...	1.70 ,,
July	... 11 ...	5.15 ,,
August	... 12 ...	4.44 ,,
September	... 11 ...	2.88 ,,
October	... 25 ...	13.15 ,,
November	... 24 ...	10.71 ,,
December	... 18 ...	7.63 ,,

The greatest rain in a day was 3.7 inches on October 14th. During the period recorded the weekly totals showed four weeks with no rain at all. The longest period without rain occurred in July and was of 17 days' duration.

The heaviest rain occurred on Nov. 7th. A shower of 1.0 inch fell in 24 minutes. Omitting several minutes of very light rain at the end of the shower the average intensity was 6.0 inches per hour, while a rate of 15.6 inches per hour was reached during the heaviest period.

The more usual values for maximum rate during a shower range between 3 and 6 inches per hour. Several records were obtained of showers exceeding 3 inches in total and reaching rates of between 7 and 8 inches per hour.

The relationship between rainfall and time of day and similar matters will not be discussed here as they have already been

much more fully covered by the official records of the Government Meteorologist.

SOIL TEMPERATURE.

A recording soil thermograph with two bulbs was available for use in March, 1928. Its application to measurements under jungle has already been discussed. In July it was installed in more permanent fashion at the laboratory with the bulbs set at depths of 2 inches and 8 inches respectively. For the first period the soil was kept bare and later a commencement was made on the investigation of the effects of different types of shading. Since the seasonal variation is insignificant compared with the diurnal temperature wave the salient features under any one set of conditions can be obtained in a comparatively short period.

The figures given below make an instructive comparison between the following three conditions (1) shaded by virgin jungle (2) unshaded bare soil (3) shaded by a layer of dry grass. Certain calculations were made on the assumption of a simple harmonic diurnal wave. This is only approximately true. The wave at 2 inches depth on a normal day rises during 7 hours (say 7 a.m. to 2 p.m.) and falls during the remaining 17 hours. The figures given represent only general results which could be improved in a more detailed report by distinguishing between wet and dry states of the ground.

- (1) Virgin Jungle. Mean soil temperature 75°F. showing only slight variations with time or depth—daily amplitude 1°, while the variation during 3 months did not exceed 2°.
- (2) Unshaded. Mean temperature near surface 88°F. Amplitude of diurnal wave at 2 inches about 35°. At this depth the minimum night reading corresponds very nearly indeed to the steady temperature under jungle (74°—76°). The maximum is thus round 111°. The amplitude falls off rapidly with depth and calculation indicates that the temperature wave is very small indeed at 2 feet.
- (3) Shaded by surface mulch of dry grass. Mean temperature 85°, daily range about 7°F. at 2" depth.

The soil is a compact sandy loam.

The result clearly emerges from these figures that, whatever the conditions subsequent to clearing of forest, the soil temperature will be unavoidably increased to a considerable depth.

A further interesting observation is that on rare overcast days (e.g. December 22nd of lowest solar radiation) the temperature at 2 inches remained throughout at a lower value than that at 8 inches, that is, the direction of heat flow was not reversed during the day,

or the loss of heat from the ground, which is normal at night, continued through the day also.

GENERAL.

Among other activities of which mention should be made was the pursuit by the Head of the Division of a research on the capillary properties of soil. This item was included in the Programme of Work under the heading of "Pure Research in Soils." The work had been begun elsewhere, and it was important to settle certain points which still remained obscure. The technique of the experiments was simple and they were carried out at home during leisure hours. A preliminary report of the results was published in a letter to "*Nature*" of Oct. 20th, 1928, and the completed manuscript was ready for the press at the end of the year. The results gave very close verification of certain theoretical deductions as to the capillary properties in an idealised soil. The main practical advance in our knowledge of soil properties made by this research was the demonstration of a hysteresis effect in the changes of capillary suction with moisture. In other words the capillary force characteristic of a soil which is losing water is higher than the corresponding value when the soil is absorbing water. This has an important bearing upon many soil studies which have been made by various workers in recent years, and in which this distinction has not been clearly realised.

The tests mentioned under "Electro-Culture" in the Programme of Work were not further pursued. It was found that the special apparatus in view had already been tried in Malaya without positive result, and a later report in the *New Zealand Journal of Agriculture* strongly confirmed this conclusion.

WILLIAM B. HAINES,

Head of Soils Division.

April 29, 1929.

ANNUAL REPORT 1928.

Including Initial Period beginning June, 1927.

BACTERIOLOGIST.

In the earlier part of the year a considerable amount of time was spent in preparing orders for apparatus and chemicals, making general preparations and surveying the relevant literature. The late arrival of some essential pieces of apparatus caused considerable delay and it was not possible to perform much work of a strictly bacteriological nature. Some preliminary work on soil biochemistry has, however, been carried out.

The investigations undertaken had reached the stages stated at the close of 1928.

THE DECOMPOSITION OF SOIL ORGANIC MATTER.

As far as local soils under rubber are concerned, there appears to be little doubt that the limiting factor in soil productivity is the organic matter present. H. Jenny, (*J. Amer. Soc. Agronomy*, 1928, 20, 1900), has recently shown mathematically that, for similar humidity factors, the nitrogen content of the soil decreases exponentially as the temperature increases. This means that less nitrogen is retained in the soil as the equator is approached. The high intensity of the rainfall and the absence of low-growing vegetation are two further factors which combine to diminish the organic matter contained in the soil on Malayan rubber estates.

Some preliminary work on the decomposition of soil humus, under laboratory conditions, was commenced in April. Measurements of the rate of decomposition were made by estimating the carbon dioxide evolved. Three different soils have been examined in this manner and, although the investigation is far from completion, several points of interest have come to light.

During the first few days a more or less uniform rate of decomposition obtains but after this a steady diminution in the output of carbon dioxide occurs. Attempts have been made to discover the reason for this decline. It does not appear to be due to lack of moisture, exhaustion of the organic material or inadequate aeration. Nor does it appear to be due to the formation of a substance toxic to the micro-organisms present. To test this last point, an experiment was stopped after being in progress for 7 months and the soil was thoroughly washed with water. This treatment in no

way affected the velocity of decomposition and, moreover, soil bacteria were able to grow in the soil washings.

It has been found, however, that "partial sterilisation" produces an effect. The soil was heated in an autoclave for 2 hours under a pressure of 15 lb. (120°C.) and after this treatment an increase in the carbon dioxide output occurred. This seems to be a point in favour of Sir John Russell's suggestion that the number of bacteria present in a soil varies inversely with the number of Protozoa present. In the present case, the "partial sterilisation" would undoubtedly prove more detrimental to the Protozoa while the spore-forming bacteria would be given a new lease of life under more favourable conditions.

This work is still in progress.

NODULE-FORMATION ON LEGUMINOUS COVER-PLANTS.

The healthy growth of leguminous plants is associated with the presence of nodules on the roots. These nodules are formed by a particular species of bacterium which is able to fix atmospheric nitrogen. As most of the leguminous cover plants grown on rubber estates are not indigenous in Malaya, it seems probable that the considerable difficulty often experienced in establishing such plants may be due, in some measure, to the absence of the appropriate nodule-forming micro-organisms in the soil. An investigation is in progress to test this point, the material in use being *Centrosema plumieri* and *Centrosema pubescens*.

DECOMPOSITION OF RUBBER SEEDS.

The question has arisen as to whether it is more economical to collect rubber seeds for oil or to allow them to rot on the ground. Although there can be little doubt that it is a more advantageous policy to sell the seeds, some experiments are being carried out on the manurial value.

From the results obtained after 6 months, it seems almost certain that if left entirely to the depredations of micro-organisms, the seeds would not disappear from the ground during the year. Under natural conditions, however, the seeds are demolished by mammals, birds and insects so that their manurial value cannot be assessed with any degree of accuracy.

ADVISORY WORK.

A minor investigation was concerned with the peaty soil on a rubber estate in Selangor. One area on this estate contains young rubber of poor growth and on which unsuccessful attempts have been made to establish cover-plants. Near by is an area

under mature rubber, which has a complete cover of mossy vegetation.

In October 1927, Dr. Haines visited this estate and, considering the poor growth to be largely due to the sterile condition of the soil, advised treatment of the young rubber area with stable manure. This suggestion was acted upon and four months later there was a sparse growth of weeds at the roots of the trees treated.

At this period some bacterial counts were made of soil under

- | | |
|-----------------------------------|----------------|
| (a) old rubber: | unmanured. |
| (b) young rubber: | unmanured. |
| (c) young rubber adjacent to (b): | stable manure. |

As was anticipated, it was found that the samples from (a) and (b) were very acid and almost sterile while area (c) was much less acid and contained about five million bacteria per gram of soil. Though this number is below the normal value, it shows that some considerable improvement has taken place as a result of the application of stable manure.

A. STEVEN CORBET,

Bacteriologist.

1st May, 1929.

ANNUAL REPORT 1928.

EXPERIMENT STATION.

The Manager of the Experiment Station assumed duty on 9th December, 1927.

ACREAGE STATEMENT.

The position as at December 31st, 1928 was as follows :—

Planted	...	...	...	88	acres.
Holed and filled,	...	...	...	22½	„
Lined	...	...	...	15	„
Cleared	...	...	...	102½	„
Cleared (not to be planted)...	...	...	...	2	„
Felled (not burnt off)	...	...	...	440	„ 670 acres.
Building sites	...	...	...	70	„
Jungle Reserves	...	...	...	1,260	„
Area under application	...	...	...	2,000	„

DISTRIBUTION OF AREAS.

Botanical Department	...	301	acres.
Soils Department	...	139	„
Pathological Department	...	230	„
Building sites	...	70	„
		740	„

It has been decided, so far as possible, to extract jungle produce from areas to be opened up. This means that the work of clearing will take considerably longer than would be the case when the usual procedure is followed. For this reason larger areas than are required for immediate planting are being dealt with.

CLEARING.

A total area of 230 acres was cleared during the year.

Details :—

All surface timber and complete stumping.	Blocks	
2, 3, 4, 8, 9 (part), 10, 12 and 13	..	94 acres.
All surface timber and 9 inch stumps Block 5	...	40 "
9 inch surface timber and 6 inch stumps Block 6	...	40 "
6 inch surface timber and (no stumping) Block 1 (part)		30 "
3 inch surface timber and (no stumping) 7, 9 (part)		
and 11	...	26 "
		230 "

Owing to the immediate need of providing certain areas for planting, the first blocks were burnt off as soon as feasible. The work of clean-clearing proved very arduous due, in the main, to the fact that no portion of the root system of jungle stumps had decomposed so that extraction was a very difficult matter. Further, stumps were "green" and, as a result, the difficulties in burning were enhanced. The whole of the area opened up during the year was high flat land—naturally well drained. But under jungle conditions there is no doubt that the water-table was high. This is borne out by the peculiar root construction revealed as a result of stumping.

HOLING.

An area of 110½ acres was completed.

Details :—

Block 2.	30	acres	—	holes	3	feet × 3	feet × 2½	feet
" 4.	2½	"	—	"	2	" × 2	" × 2	"
" 4.	10	"	—	"	1½	" × 1½	" × 1½	"
" 6.	40	"	—	"	2	" × 2	" × 2	"
" 7.	10	"	—	"	2	" × 2	" × 2	"
" 8.	14	"	—	"	2	" × 2	" × 2	"
" 9.	8	"	—	"	2	" × 2	" × 2	"

N.B.—Two rows in each of Blocks 7 and 8 were not holed. Crow-bar planting was the method employed for these rows.

PLANTING.

The area planted during the year was 88 acres.

Details :—

Block 2	20	acres	Spacing.
			30 feet × 30 feet
" 6	40	"	22 " × 22 "

Block 7	10 acres	22 feet × 22 feet
„ 8	10 „	22 „ × 22 „
„ 9	8 „	22 „ × 22 „
	—	
	88 „	
	—	

Block 2. (30 acres—Museum Block).

Planting material in this block comprises stumps, seedlings (untopped) and basket plants. In all 482 stumps 118 seedlings and 405 basket plants have been put out to-date.

Block 4. (Portion reserved for Mr. Morris).

356 Basket plants have been put out in this area.

Block 4. (Portion reserved for Mr. Kaimal).

56 holes were planted with seed at stake and 96 holes with germinated seed.

These small areas are not included in the planted area.

Block 5. (40 acres).

This area has been ready for planting for some time but work will not be carried out here until budded stumps are available from our own nursery.

Block 6. (40 acres—Manurial).

This area is planted in stumps.

Block 7. (10 acres).

Planting here is one third stumps, one third basket plants, and one third seed at stake.

Block 8. (10 acres).

This is a duplication of Block 7.

Block 9. (8 acres).

Planted with basket plants.

NURSERIES.

Block 1. (General utility—1 acre).

This nursery was put down to cover unforeseen contingencies.

Block 4. (Botanical—5 acres).

Except that 16 beds are reserved for Mr. Mann and one bed is used for germinating seed, the whole of this nursery is planted.

Seed was germinated before being put out. In all there are some 64,000 plants.

ROADS AND BRIDGES.

Extensive roading is being undertaken. To the end of the year 130 chains of clearing and earth-work had been completed. This work is being pushed on and arrangements are being made for metalling same.

DRAINAGE.

Except for certain rough drains cut to facilitate clearing and rough clearing of the Sungei Payong, no drainage was done.

The opened area though flat, is high, and naturally well drained. The soil is a very open one allowing of very rapid movement of water. So that drainage requirements will not be extensive.

SILT-PITTING AND BUNDING.

Except for a few chains of silt-pitting cut experimentally, no work was done during the year.

But for one small ravine, the lie of land, over the area opened up, is either flat or very gently undulating. Even then, owing to the extremely free nature of the soil, surface wash would be considerable unless covers were established and silt-pitting or bunding resorted to. Bunding or a combination of terrace and bund would probably prove more efficient than silt-pits, the latter are likely to fall in rapidly.

An interesting experiment in bunding has been laid down for Block 3 through which area the ravine, above referred to, passes.

LEVELLING.

Where clean-clearing had been carried out it was necessary to fill in the excavations resulting from the removal of stumps. Failing this, some planting would have been 5 to 6 feet below normal surface level and in other cases 3 to 4 feet above and on excavated earth. In both cases the results of such planting would have been bad.

In addition to this work further levelling was carried out in Blocks 8 (10 acres), 9 (4 acres—part), 10 (10 acres), 12 (5 acres), and 13 (5 acres). In these blocks the land was of a very hillocky nature. As this characteristic would tend to militate against the success of the experimental work here, all hillocks were cut away and hollows filled in.

COVER-CROPS.

Vigna was planted in Blocks 2 (30 acres), 4 (10 acres—part) and 5 (40 acres). Owing to the planting being followed by two months drought, this cover did not come away well. But, in view of the fact that the plants have managed to hang on, I think we may expect a good cover following rain.

Preparations are being made with a view to the planting out of various covers elsewhere.

A collection of covers is being made and these will be planted in Block 13 where $2\frac{1}{2}$ acres have been reserved for this purpose.

PESTS AND DISEASES.

Rats, grasshoppers and crickets have been troublesome but damage has only been slight. These pests are well controlled though it has been necessary to use eight dozen traps to gain effective control of rats.

Elephants are known to frequent the Sungei Buloh Forest Reserve and so constitute a menace. As a means of protection a belt of felled jungle, two chains in width is left unpruned around the whole planted area. This belt will be extended as necessity arises.

HEALTH.

Care has been taken to reserve a building site which lends itself to easy control malarially and I am satisfied that no difficulty will be experienced in this direction. Special work, tending to make for good health conditions, is in hand.

Health during the year was very satisfactory.

BUILDINGS.

Except for one set of temporary lines and a temporary tool shed no buildings were erected during the year.

The cost of erecting all kongsis for the housing of Chinese contract labour was borne by the contractors.

Plans for Guest House, Clerk and Conductor's bungalows and cooly lines have been prepared and building operations were commenced early in the New Year.

EXPLOITING JUNGLE.

Arrangements were made with the Forest Department to extract jungle produce from the area being opened up. As a result large quantities of squared hard timber, scaffold poles, mining

drops, fire-wood and charcoal have been extracted.

Now that the Manager has complete control (previously a dual control existed) far larger quantities of jungle produce are being worked. This is because a clearing contractor can better afford to market poor class timber than can a man who is purely engaged on working timber.

Revenue so obtained is considerable and it is hoped that the Experiment Station may benefit to some extent though this matter has yet to be settled.

I have no hesitation in saying that, unless a property were unusually favourably situated, the working of jungle produce would not prove practicable or profitable.

Firewood would provide the bulk of revenue obtained. After sawing and splitting, this timber cannot be kept for long and so an immediate market is necessary.

Where new land is being taken up for planting, opening up is not found to be confined to one or two estates. A glut would result if a number of estates were working firewood in the same district at the same time and such produce would become unmarketable.

It is to be remembered that it takes three times as long to clear an area when extracting timber before planting than by piling and burning direct.

GENERAL.

Opening up and planting would have been more rapid but for the extremely arduous work in clean clearing and heavy work entailed in levelling in some blocks.

A real start was not made until March since, in the first place, a certain amount of survey work was necessary and access was difficult. The erection of buildings and the obtaining of labour occupied some little time. In regard to the latter, no contractor would make a start until after Chinese New Year.

D. S. GARDNER,

Manager,

Rubber Research Institute Experiment Station.

Kepong.

23rd March, 1929.

THE RUBBER RESEARCH INSTITUTE OF MALAYA. (Incorporated.)

BALANCE SHEET AS AT 31st DECEMBER, 1928.

LIABILITIES.		ASSETS.	
	\$ c.		\$ c.
Sundry Creditors—		Land and Buildings—	
At Experiment Station	...	L. 132, Ampang Road :	
Robinson and Co., Ltd.	...	Land as per last Balance Sheet ...	10,755 00
Swan and Maclaren	...	Ampang Villa, Building as per	
Heffer and Sons, Ltd.	...	last Balance Sheet ...	17,476 88
Kyle Palmer and Co., Ltd.	...	Less depreciation for year ...	448 12
Board Members Fees and Expenses	...		17,028 76
Sundry other Creditors	...	Director's New House as per last	
	21,688 27	Balance Sheet ...	42,270 80
		Add cost of Sanitary Scheme ...	2,818 93
Deposits—			45,089 73
For Future Publications :		Less depreciation for year ...	1,224 56
Manual No. 3 ...	5 75		43,865 17
Bulletins ...	32 00		
	57 75		
Reserves—			
Staff Leave Pay :	\$ c.		
At 31st December, 1927	23,746 00	2. Land behind Ampang Villa :	
Add for 1st half year, 1928	21,149 00	As per last Balance Sheet ...	4,850 00
Add for 2nd half year, 1928	14,177 00	Add Legal Fees re acquisition ...	151 35
	59,072 00		5,001 35
Less paid during year	4,485 48		
	54,586 52	3. 5. Circular Road :	
		Land as per last Balance Sheet	17,147 08
		Old Building as per last Balance	
		Sheet ...	13,678 69
		Add cost of Water Pipes ...	60 00
			13,738 69
		Less depreciation for year ...	353 74
			13,384 95
		Carried forward	30,532 03
			76,650 28

BALANCE SHEET AS AT 31st DECEMBER, 1928 (cont.).

LIABILITIES—(cont.).

	\$	c.	\$	c.	\$	c.
Staff Passages :						
At 31st December, 1927	15,389	00			21,746	02
Add for 1st half year, 1928	8,230	00				
Add for 2nd half year, 1928	7,017	00				
	<u>30,636</u>	00				
Less paid during year	8,095	87				
			22,540	13		
Government Loan of \$750,000—					77,126	65
Amount drawn to date	...		70,000	00		
Interest accrued due	...	825	00			
Reserve for Sinking Fund Payment	400	00	1,225	00		
					71,225	00
Accumulated Fund—						
Balance at 31st December, 1927	...		699,587	17		
Add Excess of Income over	...					
during 1928	...		110,845	27		
					816,432	44
Carried forward ...						

ASSETS—(cont.)

	\$	c.	\$	c.	\$	c.
Brought forward			30,332	03		
Land & Buildings, cont.						
Three New Houses :						
As per last Balance Sheet	74,140	12				
Add Electrical Installation	1,225	00				
Architects' Fees	801	30				
	<u>76,166</u>	52				
Less depreciation for year	2,017	35				
			74,143	17		
4, 163, Anpang Road :						
Land as per last Balance Sheet			31,440	35		
Old Building as per last Balance Sheet	13,928	09				
Add cost of Water Pipes	40	00				
	<u>13,968</u>	09				
Less depreciation for year	336	05				
			12,732	04		
First Five Houses :						
As per last Balance Sheet	81,709	62				
Add additions during year	7,128	81				
Add Architects' Fees	1,018	12				
	<u>89,856</u>	55				
Less depreciation for year	2,502	46				
			87,354	09		
Carried forward ...						

131,526 48

Carried forward ... 313,157 96

BALANCE SHEET AS AT 31st DECEMBER, 1928 (cont.).

LIABILITIES—(cont.).	\$			ASSETS—(cont.)		
	\$	c.	c.	\$	c.	c.
Brought forward	986,530	11		Brought forward		313,157 96
Land & Buildings.—contd.						
5, 3½ mile, Ampang Road :						
Land as per last Balance Sheet ...				...		45,422 50
Second Five New Houses as per last Balance Sheet				1,741	40	
Additions during year				71,363	63	
				73,105	03	
Less depreciation for year				1,827	63	
						71,277 40
Laboratory Buildings at 2½ mile, Damansara Road—						
As per last Balance Sheet						79,674 54
Additions during year						2,648 50
						82,323 04
Less depreciation for year						2,109 15
						80,213 89
Plant and Machinery—						
Electric plant :						
As per last Balance Sheet				3,344	43	
Additions during year ...				9,418	00	
				12,762	43	
Less depreciation for year				3,190	61	
						9,571 82
General Machinery :						
As per last Balance Sheet				27,345	18	
Additions during year				3,172	65	
				30,517	83	
Less depreciation for year				4,577	70	
						25,940 13
						35,511 95
Carried forward	986,530	11		Carried forward		345,583 70

BALANCE SHEET AS AT 31st DECEMBER, 1928—(cont.).

LIABILITIES.—(cont.)		ASSETS.—(cont.)	
\$	c.	\$	c.
Brought forward ...	986,530 11	Brought forward	545,583 70
Bungalow Furniture—		Bungalow Furniture—	
As per last Balance Sheet		As per last Balance Sheet	
Additions during year ..		Additions during year ..	
		30,320 55	
		13,929 11	
Less depreciation for year		44,249 66	
		3,318 75	
Office and Laboratory Furniture		40,930 91	
As per last Balance Sheet		As per last Balance Sheet	
Additions during year ..		Additions during year ..	
		10,332 98	
		3,992 94	
Less depreciation for year		14,325 92	
		1,074 45	
Laboratory Equipment and Apparatus—		Laboratory Equipment and Apparatus—	
As per last Balance Sheet		As per last Balance Sheet	
Additions during year ...		Additions during year ...	
		37,179 00	
		36,444 58	
Less depreciation for year		73,623 58	
		14,724 72	
R.R.I. Experiment Station -		R.R.I. Experiment Station -	
Capital Expenditure to date		Capital Expenditure to date	
Motor Lorry—		Motor Lorry—	
As per last Balance Sheet		As per last Balance Sheet	
Less depreciation for year		Less depreciation for year	
		1,584 19	
		396 05	
1,188 14		1,188 14	
Carried forward ..	986,530 11	Carried forward ...	732,988 73

BALANCE SHEET AS AT 31st DECEMBER, 1928—(cont.).

LIABILITIES—(cont.).		\$		c.		ASSETS—(cont.).		\$		c.	
Brought forward		986,530		11		Brought forward		732,388		73	
						Library Books—					
						As per last Balance Sheet		1		00	
						Purchase of Books during year		2,504		84	
						Purchase of Periodicals during year		2,800		36	
								5,306		20	
						Less depreciation for year		5,305		20	
								1		00	
						Suspense Account		200		40	
						Stocks in Hand—					
						Petrol and Oil		9		15	
						Stationery		677		02	
						Teak Planks		362		28	
								948		45	
						Payment in Advance					
						Against Orders placed		272		38	
						Against Telephone Subscriptions					
						Insurance, Premium, etc.		546		67	
								549		05	
						Sundry Deposits—					
						Against Water Supplies, Telephones, etc.		160		00	
						Advances to Staff for Motor Cars, etc.					
						European Staff		6,432		94	
						Subordinate Staff		607		00	
								7,546		94	
Carried forward		986,530		11		Carried forward		741,664		17	

LIABILITIES.—(cont.)		ASSETS—(cont.).	
\$	c.	\$	c.
Brought forward ...	986,530 11	Brought forward ..	741,664 17
Sundry Debtors		Sundry Debtors	
F.M.S. Government	...	F.M.S. Government	55,036 00
S.S. Government	...	S.S. Government	11,118 00
Kedantan Government	...	Kedantan Government	2,778 54
Johore Government	...	Johore Government	25,000 00
Kedah Government	...	Kedah Government	1,750 00
Trengganu Government	...	Trengganu Government	600 00
			96,282 54
At Experiment Station	749 50	At Experiment Station	749 50
Sale of Publications	1,710 00	Sale of Publications	1,710 00
Sundry Other Debtors	303 60	Sundry Other Debtors	303 60
			2,843 10
Cash at Bank and in Hand:		Cash at Bank and in Hand:	
Rubber Growers' Association, London	...	Rubber Growers' Association, London	...
Chartered Bank, Kuala Lumpur	...	Chartered Bank, Kuala Lumpur	...
Fixed Deposits	100,000 00	Fixed Deposits	100,000 00
Board's Account	12,568 36	Board's Account	12,568 36
Working Account	23,864 14s	Working Account	23,864 14s
Experiment Station Account	8,251 40	Experiment Station Account	8,251 40
Petty Cash—		Petty Cash—	
Laboratory	10 64	Laboratory	10 64
Experiment Station	165 87	Experiment Station	165 87
			144,683 90
			116 51
			145,710 30
			986,530 11

(Sd.) V. LOUIS CACHEMAILLE,
Secretary.
11th January, 1929.

(Sd.) F. W. SOUTH,
President.
30th January, 1929.

We have audited the above Balance Sheet and Income and Expenditure Account with the books and vouchers of the Institute and certify same to be correct according to the best of our information and explanations given to us and as shown by the books of the Institute.

Kuala Lumpur,
19th January, 1929.

(Sd.) GIBSON ANDERSON BUTLER & CO.,
Chartered Accountants, Auditors.

EXPENDITURE.

To Board and Committee Meetings—
Fees to Members
Expenses of Members

To Salaries and Allowances—

1. European Staff :

(a) General and Office
(b) Research
(c) Field

2. Subordinate Staff :

(a) Office Clerks
(b) Research Assistants
(c) Field Conductor
(d) Laboratory Attendants

To Provident Fund Contributions—

(a) European Staff
(b) Subordinate Staff

To Reserve for Staff Leave
" " Passages

To Medical and Hospital Charges
" Dental Treatments
" Travelling Expenses of Staff
" Recruitment of Staff

Carried forward ...

301,956 85

INCOME.

By Contributions received—

F.M.S. Government, January to November
S.S. Government, o/a 1928

Johore Government, 1st half year

Kedah Government, January to November

Kelantan Government, January to September

Trengganu Government, January to September

Contributions accrued and since received—

Johore Government, 2nd half year

Contributions accrued and not yet received—

F.M.S. Government, December

S.S. Government, balance 1928 Estimated

Kedah Government, December

Kelantan Government, 4th quarter 1928

Trengganu Government, 4th quarter 1928 Estimated

Miscellaneous Receipts—

Bank Interest

Electric Current supplied to Bungsar Estate, Manager's Bungalow

From Estates for Conductors' Expenses

Carried forward ...

426,556 82

Dr. INCOME AND EXPENDITURE ACCOUNT FOR YEAR ENDED 31st DECEMBER, 1928—(cont.). Cr.

EXPENDITURE—(cont.).		INCOME—(cont.).	
To Publications—		Brought forward ...	
Printing and Distribution of :			
Manual No. 1	343 68		
Manual No. 2	1,437 91		
Quarterly Journal	2,329 94		
To Depreciation	4,111 53		
To Balance, Excess of Ordinary Income over	43,406 54		
Ordinary Expenditure carried down	30,215 27		
	<u>426,556 82</u>		
To Balance, Excess of Total Income over Total			
Expenditure for year, carried to Balance			
Sheet	116,845 27		
	<u>116,845 27</u>		
By Excess of Ordinary Income over Ordinary			
Expenditure for year brought down	...		
	30,215 27		
By Contributions received in respect of pre-			
vious periods—			
S.S. Government :			
Balance of Contribution, period Decem-			
ber, 1924 to December, 1925	12,385 00		
Balance for year 1926	25,705 00		
For year 1927	48,540 00		
	<u>86,630 00</u>		
	<u>116,845 27</u>		

(Sd.) V. LOUIS CACHEMAILLE,
Secretary.
11th January, 1929.

(Sd.) F. W. SOUTH,
President.
26th January, 1929.

(Inld.) G. A. B. & Co.

